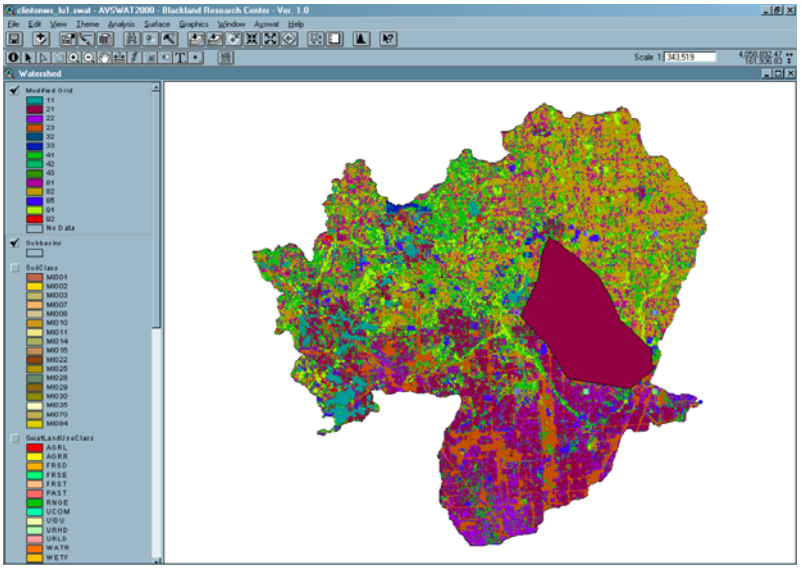
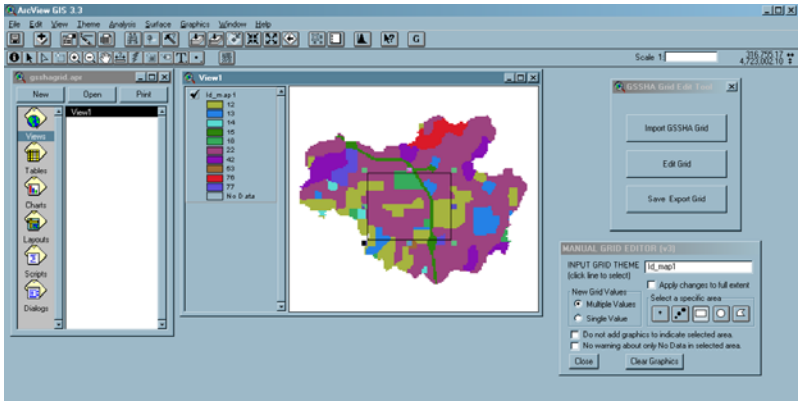
U.S. Army Corps of Engineers
Detroit District

Clinton River Watershed Model User Manual





Prepared by
W.F. Baird & Associates Ltd.
Madison, Wisconsin

May 16, 2005

CLINTON RIVER WATERSHED MODEL
USER MANUAL

Prepared for:

US ARMY CORPS OF ENGINEERS
DETROIT DISTRICT
CONTRACT # DACW35-01-D-0009/0012

Prepared by:

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MADISON, WI

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1.0 INTRODUCTION

The following user manual is designed to complement the Clinton River Watershed Sediment Transport Study Report (USACE, 2005) as well as the existing user manuals for the numerical models (SWAT and GSSHA) used in the Clinton River Watershed Modeling System. The following manual gives the users of the Clinton River watershed models some additional information about the set up and execution of the SWAT and GSSHA models as well as certain insight gained through the development of these models for this specific watershed. In addition, the GIS projects set up for the Clinton River Watershed Sediment Transport Study are introduced and explained.

Guidance on how to use the SWAT and GSSHA models, where they are applicable, as well as example applications are given in USACE (2005), Sections 4 and 7.

2.0 SWAT

In addition to the accompanying report (USACE, 2005), the user has at their disposal several documents pertaining to the SWAT model and AVSWAT interface (Di Luzio, et al., 2001; Neitsch, et al., 2002a; Neitsch, et al., 2002b). It is assumed that the user will utilize these documents as a guide for general SWAT model setup and execution. The SWAT website also provides a list of SWAT peer reviewed publications. This list is included in Appendix UM1. The following sections are designed to present some of the most relevant information for getting started using the Clinton River SWAT model as well as walk the user through some model modifications to ultimately rerun the SWAT model to see the change in results. For this project, the ArcView interface (AVSWAT) was used to set up and run the SWAT model, thus this manual will assume the user is using the same.

2.1 System Requirements and Setup

The computer requirements and software setup for the Clinton River watershed SWAT model are similar to those described in Section 2 of the AVSWAT User Guide. The following system requirements are taken directly from the AVSWAT User Guide:

> The SWAT2000/Arcview Interface requires:
>
> - Personal computer using a Pentium I processor or higher, which runs at 166 megahertz or faster
> - 64 megabytes RAM minimum
> - Microsoft Windows 95, 98, NT 4.0 or Win2000 operating system with most recent kernel patch*

- VGA graphics adapter and monitor. *The interface works best when the resolution is set to 800 x 600 or 1024 x 768 pixels, the color palette is set to 8-bit (256 colors) or 16-bit (32768 colors) and the display font size is set to* ***small fonts****.*
- 50 megabytes free memory on the hard drive for minimal installation and up to 300 megabytes for a full installation
- ArcView 3.1 or 3.2 (software)
- Spatial Analyst 1.1 or later (software)
- Dialog Developer 3.1 or later (software – included with ArcView)

While 50 MB is adequate hard drive space for installing the interface, you may need considerably more space to store the tables generated when the interface processes the map layers.[†] We have found that a 2 gigabyte hard drive works very well for storing ArcView, the SWAT/ArcView interface, and project maps and tables.

[*]Microsoft constantly updates the different versions of windows. This interface was developed with the latest version of Windows and may not run with earlier versions. Patches are available from Microsoft.

[†] The space required to create a SWAT project with the SWAT/ArcView interface depends on the resolution of the maps used. While testing the interface, a 10-meter resolution DEM map layer taking up only 6 MB of space was processed. At one point in the analysis of the map, the interface had filled 350 MB of storage with data.

An important note about the software requirements is that to use the AVSWAT interface the user not only needs ArcView 3.X but also the Spatial Analyst Extension for ArcView, which is a separate cost.

Section 2 of the AVSWAT User Guide (Di Luzio, et al., 2001) also provides instructions on how to install the SWAT ArcView interface. The files used for installation can be downloaded directly from the official SWAT website: http://www.brc.tamus.edu/swat/.

Order of installation:

1. ArcView 3.x
2. Spatial Analyst
3. AVSWAT
4. BASINS (optional – install if the user would like to use GenScn for output processing)

2.2 Data Requirements

The required datasets are described in detail in the AVSWAT User Guide, Section 3. The following is a summary of the datasets needed; in addition, comments are given to further expand upon the requirements of certain datasets:

Required ArcView Map Themes:

- ArcInfo-ArcView GRID—Digital Elevation Model (DEM)
- ArcInfo-ArcView GRID or Shape—Land Cover/Land Use – *the land cover/land use is reclassified when brought in to AVSWAT, the user should double-check the data table used for reclassification to be sure it corresponds correctly to their dataset*
- ArcInfo-ArcView GRID or Shape—Soil – *AVSWAT is designed to use the NRCS STATSGO soil dataset, though a pre-processor for the more detailed SSURGO soil dataset has been developed at Texas A&M University and can be downloaded at http://lcluc.tamu.edu/ssurgo/; the SWAT model developed for the Clinton River watershed used the STATSGO soil dataset*
- ArcInfo-ArcView GRID or Shape or Draw Manually—DEM Mask (optional)
- ArcInfo-ArcView Shape—Stream Delineation (optional)

The GIS datasets used in the Clinton River watershed SWAT model are listed in Table 4.1. It is important to remember that all GIS data sets must have the same projection to use them in AVSWAT.

Required ArcView Tables and Text Files:

- Subbasin Outlet Location Table (dBase Table)
- Watershed Inlet Location Table (dBase Table)
- Land Use Look Up Table (dBase or ASCII) –*the table developed for the Clinton River watershed SWAT model for use with the NLCD land use dataset is given in Table 2.1.*
- Soil Look Up Table (dBase or ASCII)
- Weather Generator Gage Location Table (dBase)
- Precipitation Gage Location Table (dBase)
- Precipitation Data Table (dBase or ASCII)
- Temperature Gage Location Table (dBase)
- Temperature Data Table (dBase or ASCII)
- Solar Radiation, Wind Speed, or Relative Humidity Gage Location Table (dBase)
- Solar Radiation Data Table (dBase or ASCII)
- Wind Speed Data Table (dBase or ASCII)
- Relative Humidity Data Table (dBase or ASCII)
- Point Discharge Data Table—Annual Loadings (dBase or ASCII)
- Point Discharge Data Table—Monthly Loadings (dBase or ASCII)
- Point Discharge Data Table—Daily Loadings (dBase or ASCII)
- Reservoir Monthly Outflow Data Table (dBase or ASCII)
- Reservoir Daily Outflow Data Table (dBase or ASCII)
- Potential ET Data Table (dBase or ASCII)

It should be noted that most of these tables and text files are not necessary to set up a simple SWAT model. Many are used to customize the model for special datasets or measured inputs.

Table 2.1: Land use reclassification table for AVSWAT

NLCD code	NLCD Land Use Category	SWAT Land Cover/Plant Type	SWAT Land Cover/Plant Type Description
11	Open Water	WATR	Water
21	Low Intensity Residential	URLD	Residential-Low Density
22	High Intensity Residential	URHD	Residential-High Density
23	Commercial/Industrial/Transportation	UCOM	Commercial
32	Quarries/Strip Mines/Gravel Pits	UIDU	Industrial
33	Transitional	RNGE	Range-Grasses
41	Deciduous Forest	FRSD	Forest-Deciduous
42	Evergreen Forest	FRSE	Forest-Evergreen
43	Mixed Forest	FRST	Forest-Mixed
81	Pasture/Hay	PAST	Pasture
82	Row Crops	AGRR	Agricultural Land-Row Crops
85	Urban/Recreational Grasses	AGRL	Agricultural Land-Generic
91	Woody Wetlands	WETF	Wetlands-Forested
92	Emergent Herbaceous Wetlands	WETN	Wetlands-Non-Forested

2.3 File Setup

All data and model files needed to run the Clinton River SWAT model are included on the accompanying CD. In order to get the model to run properly please follow these instructions:

- Copy **ClintonSWAT** folder from the CD to c:\ drive.
- Copy **MI** folder from CD to \\AVS2000\AvSwatDB\AllUs\statsgo.
- Copy **gridedit.avx** from CD to \\ESRI\AV_GIS30\ARCVIEW\EXT32.

After each file or folder is copied, be sure to uncheck Read Only in the properties dialog for each file/folder. If the files are left as "Read Only" the SWAT model will not run properly.

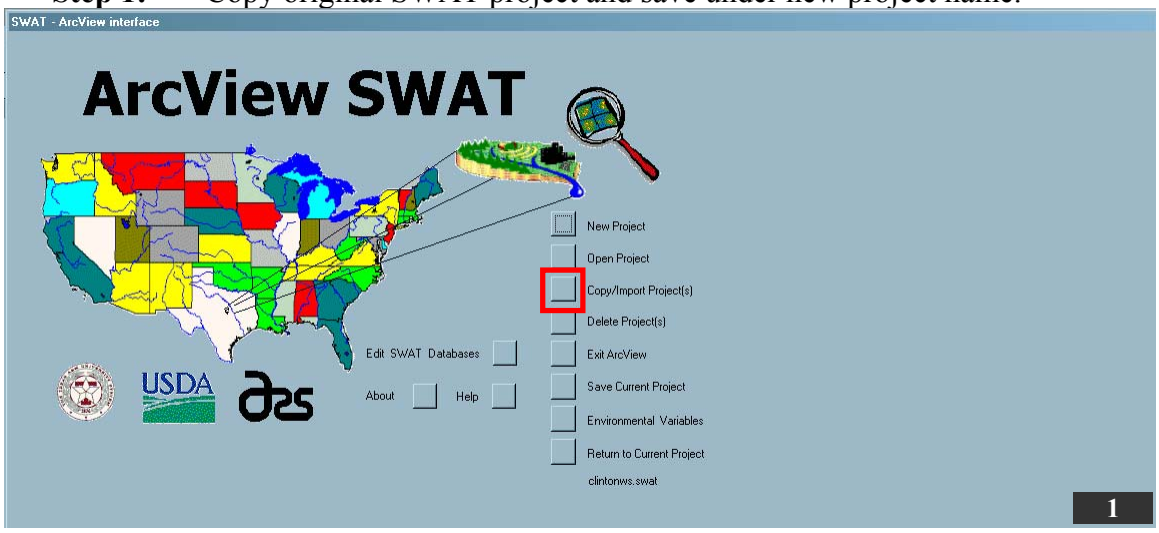
In the following tutorials, some folder locations (pathnames) may be different from what the user will have on their computer, depending on what drive the SWAT model was installed.

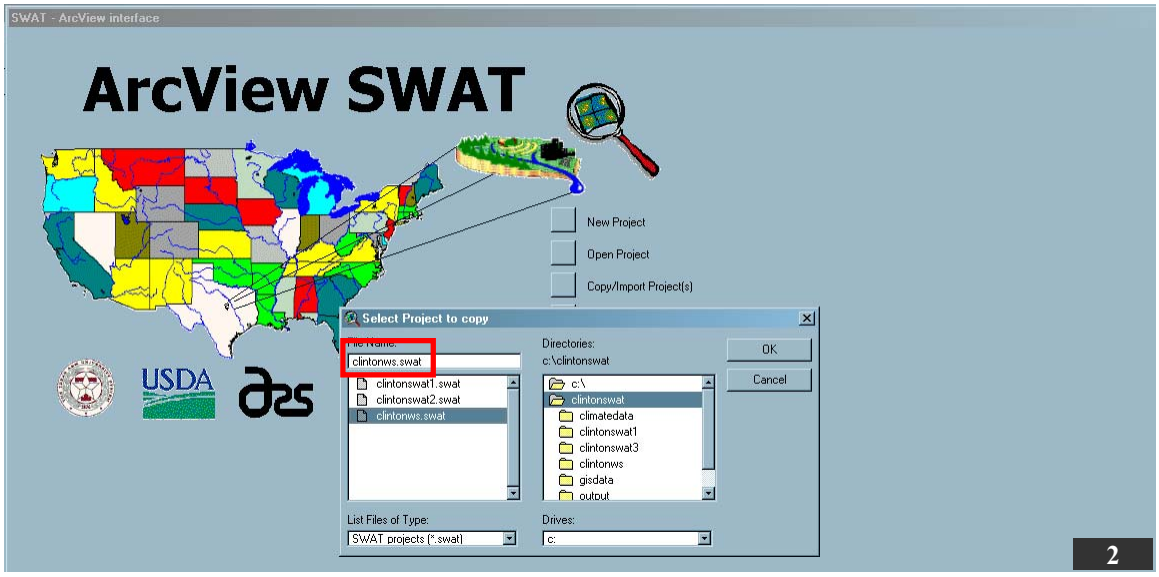
2.4 SWAT Set Up For Individual Subbasin Tutorial

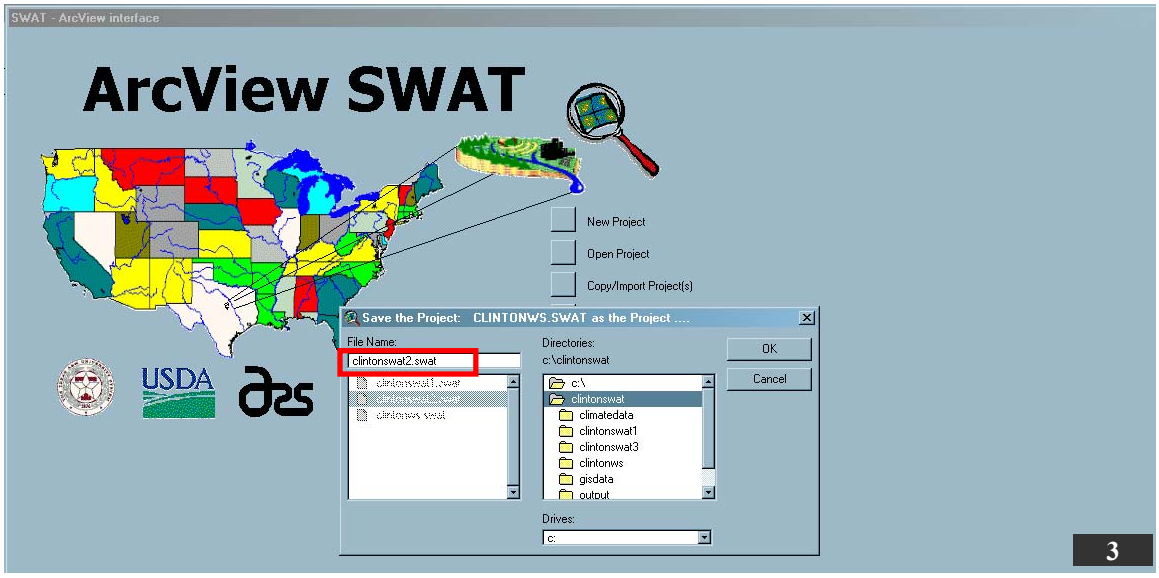
The following tutorial shows how to set up the Clinton SWAT model for an individual subbasin by starting with the overall watershed SWAT model (clintonws.swat).

The red boxes on the following screen images show where the user needs to click or type; the yellow boxes are to draw the user's attention (no action is required); and the red numbers indicate the order in which the actions need to occur.

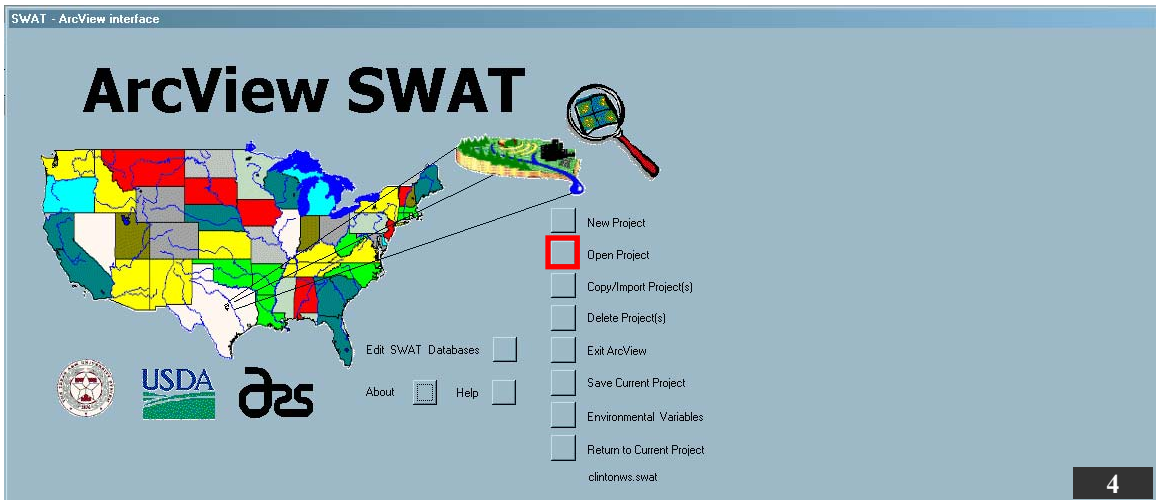
Step 1: Copy original SWAT project and save under new project name.

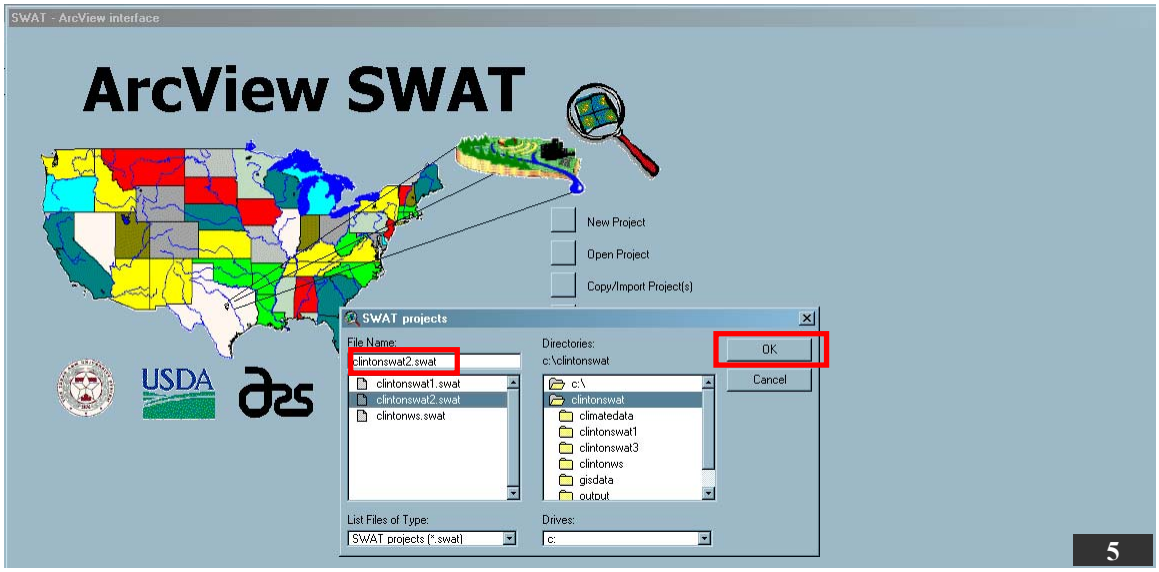




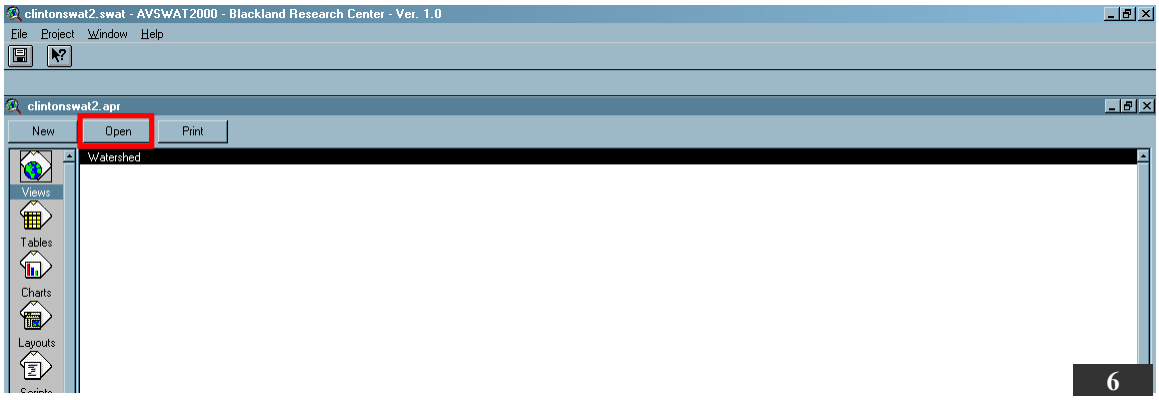


Step 2: When the copy process is finished, click **Open Project** to open the newly created project.

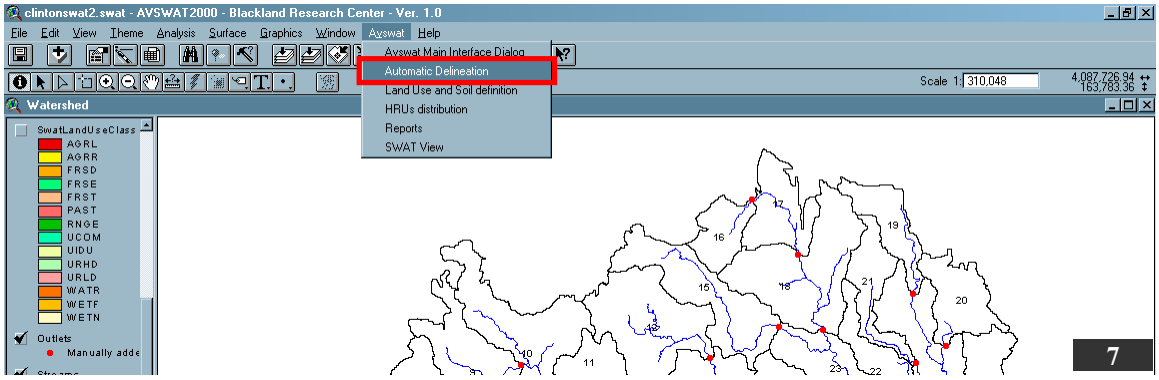




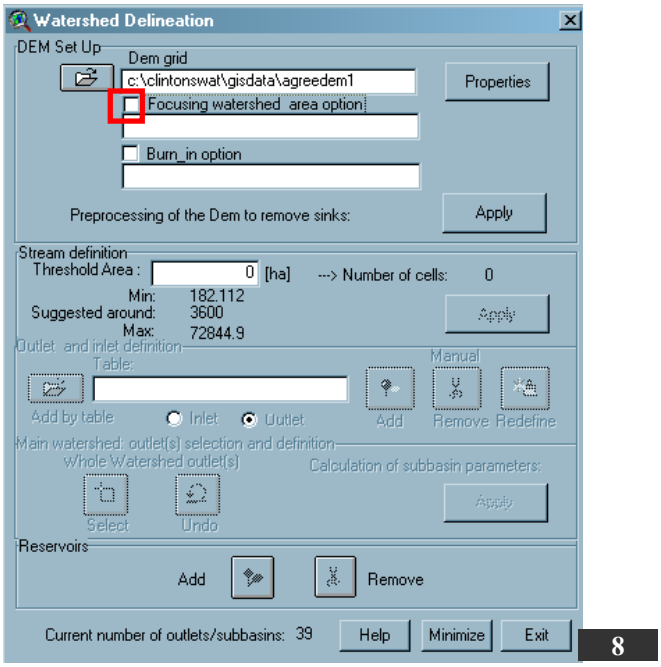
Step 3: Open the **Watershed** view.



Step 4: Open the **Automatic Delineation** dialog box.



Step 5: To mask the desired subbasin area, click the box next to **Focusing watershed area option**. Click **Manually delineate**, though other options are available. Click **No** when asked to Edit the previous shape of mask area.



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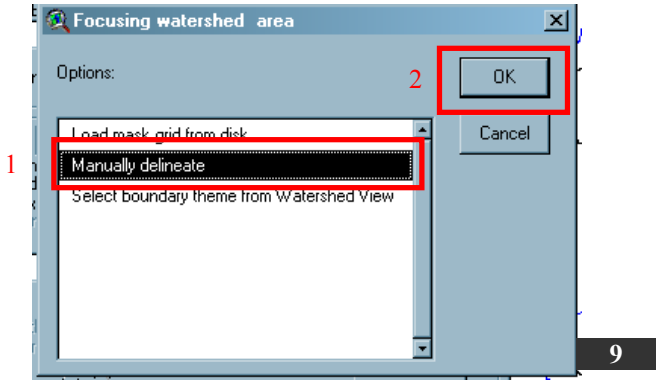

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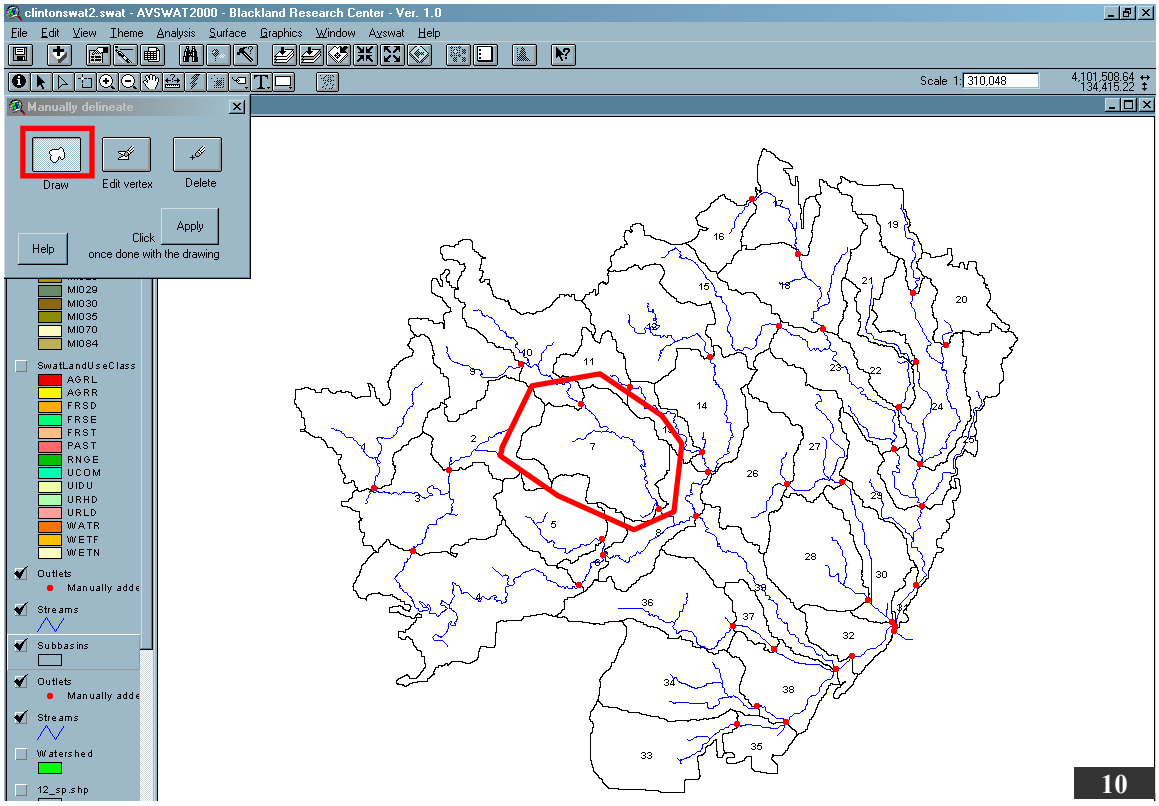
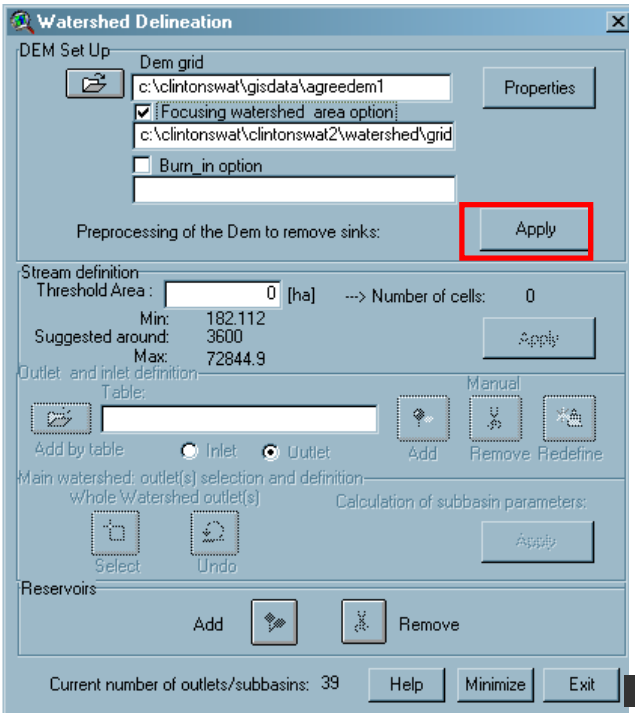
Step 6: Draw a line around the desired subbasin (in the case the Paint Creek subbasin) using the **Draw** tool. This will create a mask so only the portion of the DEM within this area will be processed – this saves processing time.



Step 7: Click **Apply** to process DEM.



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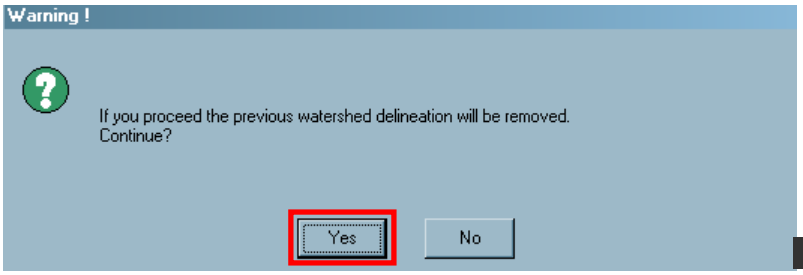

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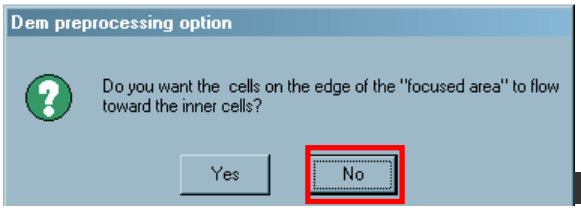
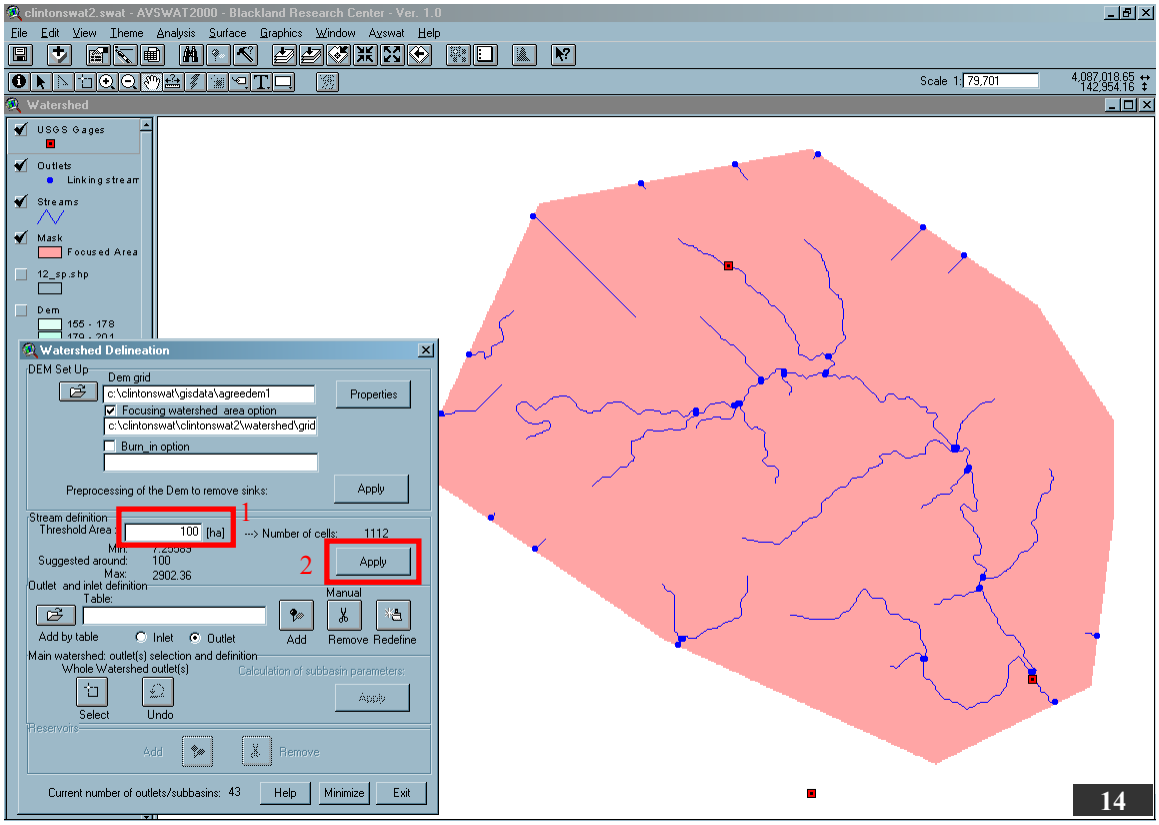
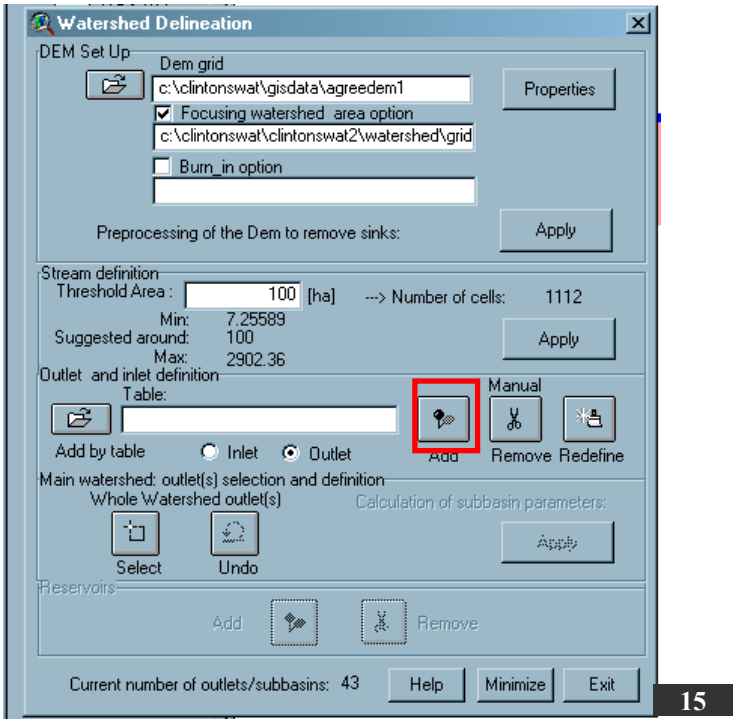


13

Step 8: Set threshold area for subbasins and click **Apply** to create stream network. The smaller the number, the more detailed the stream network generated.



Step 9: To determine location for outlet of basin, open the USGS gage shapefile and add an outlet at the gage location. This allows for direct comparison of SWAT output to gage measurements.



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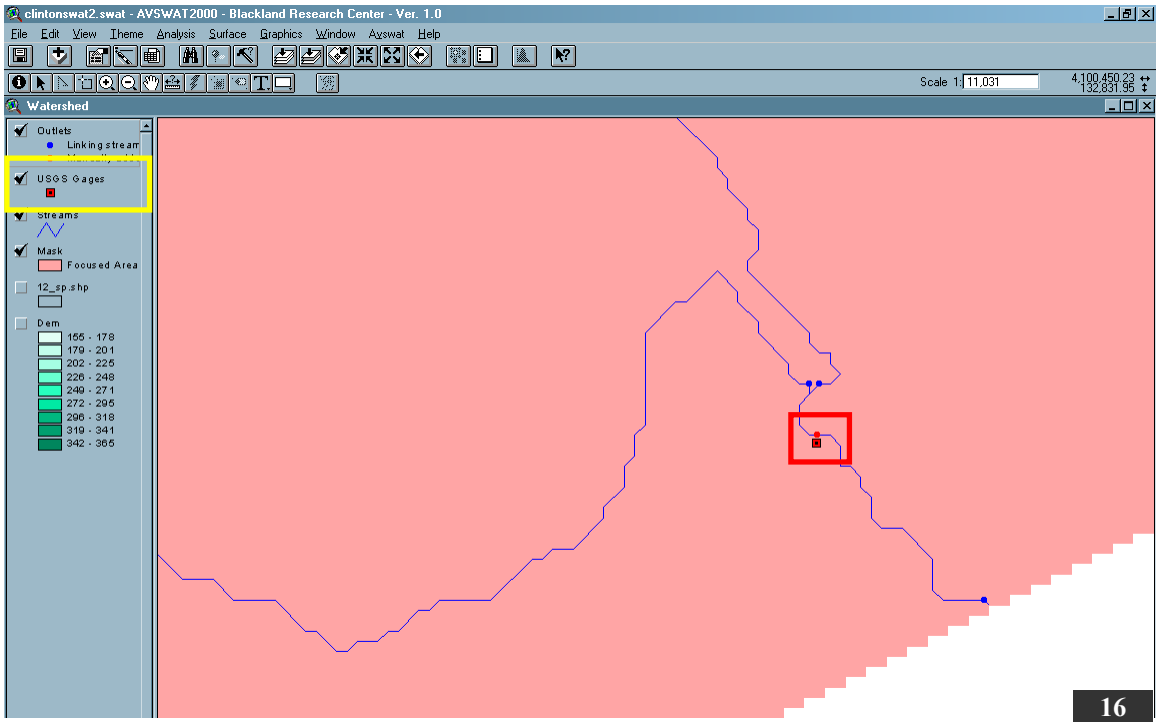

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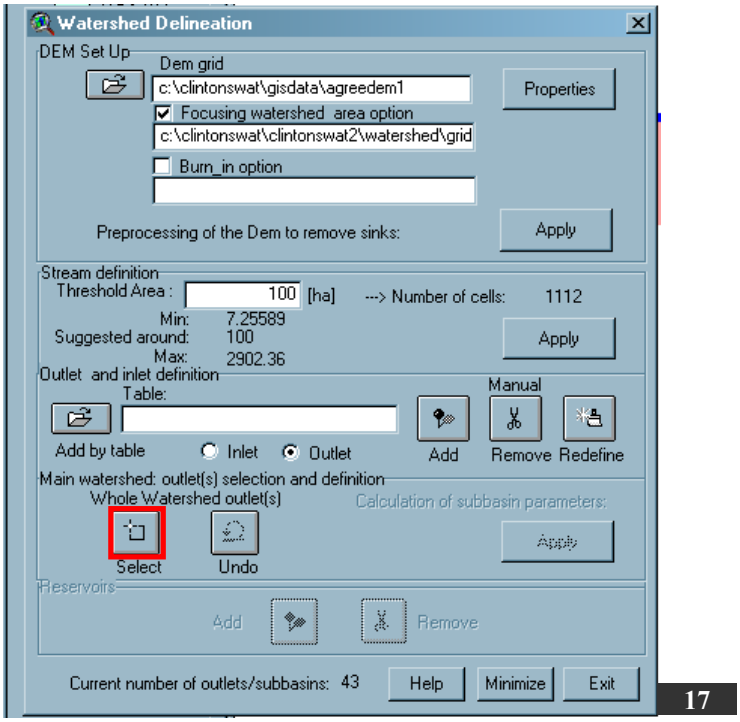
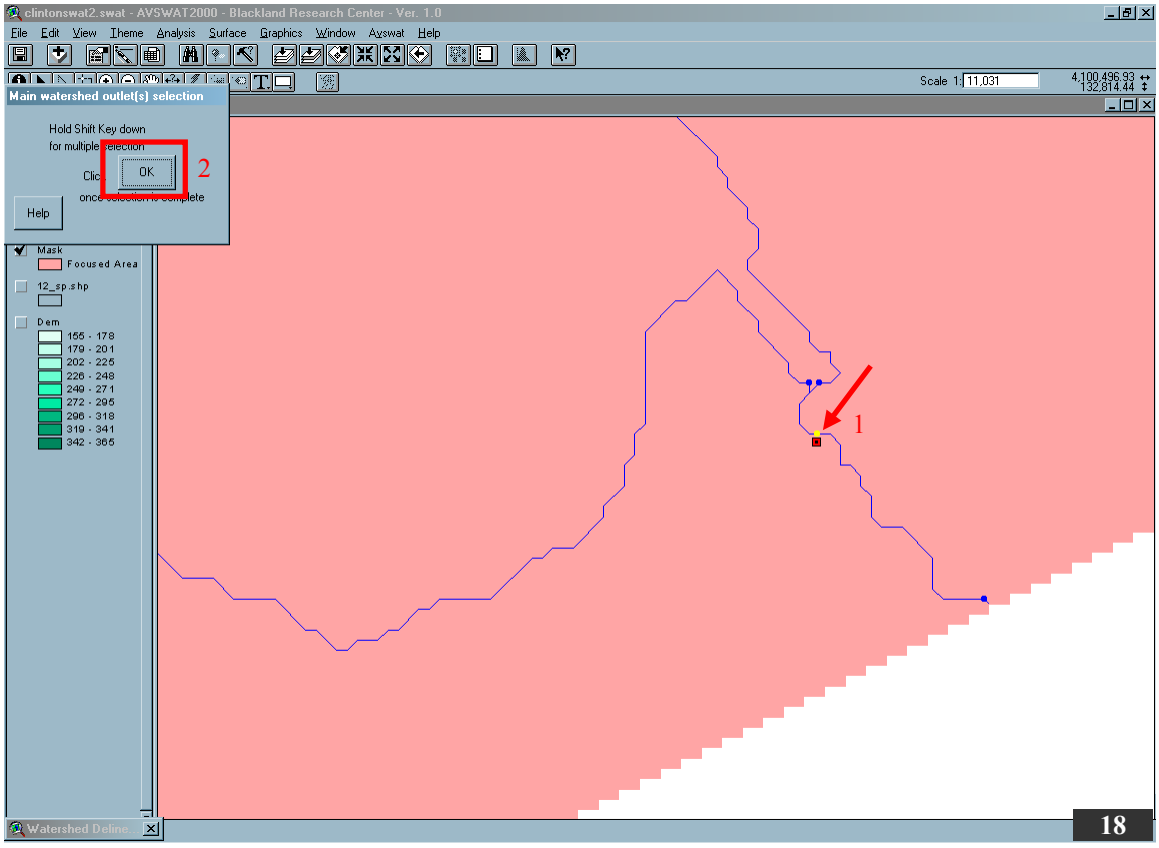
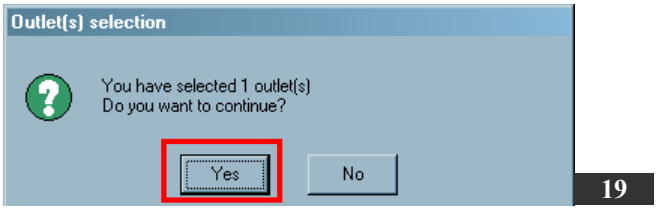
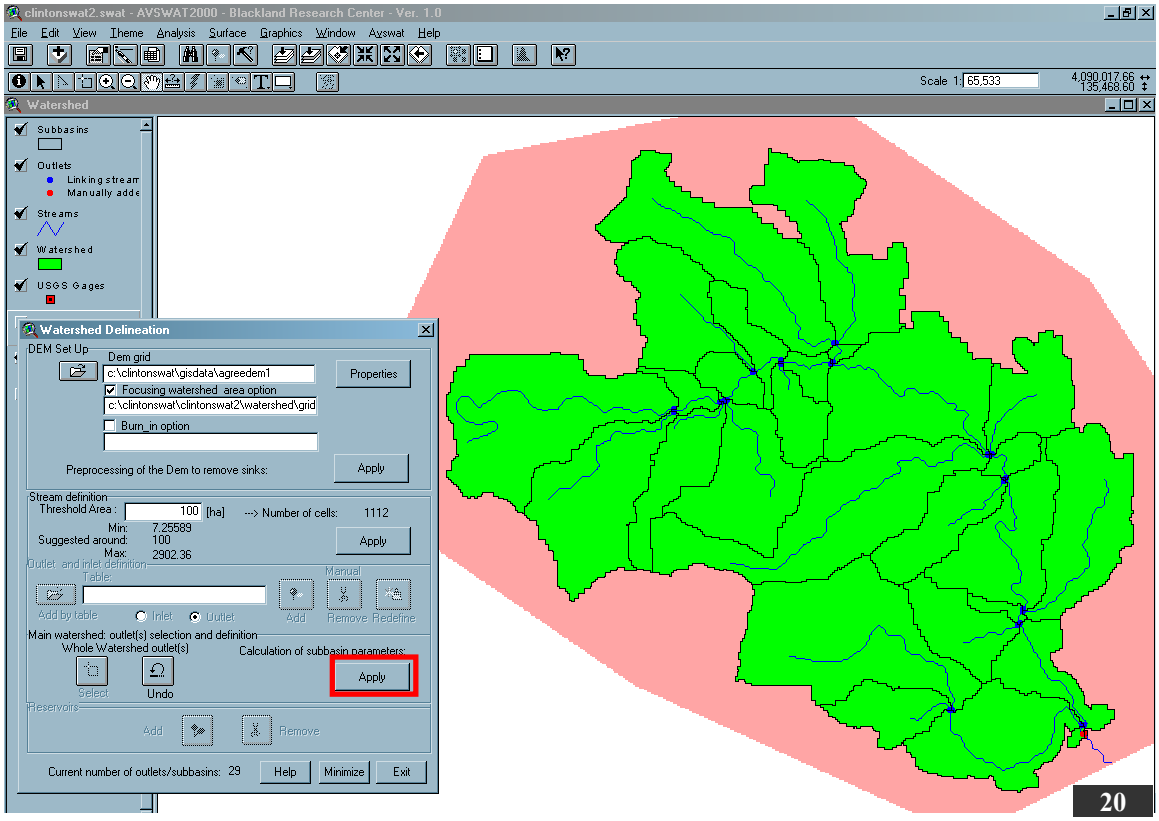
Step 10: Select gage location for whole watershed outlet.



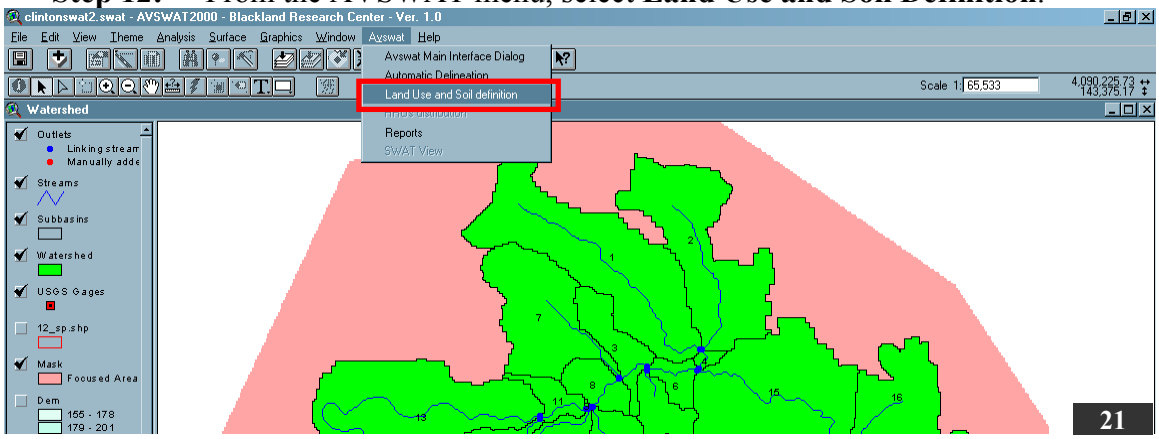




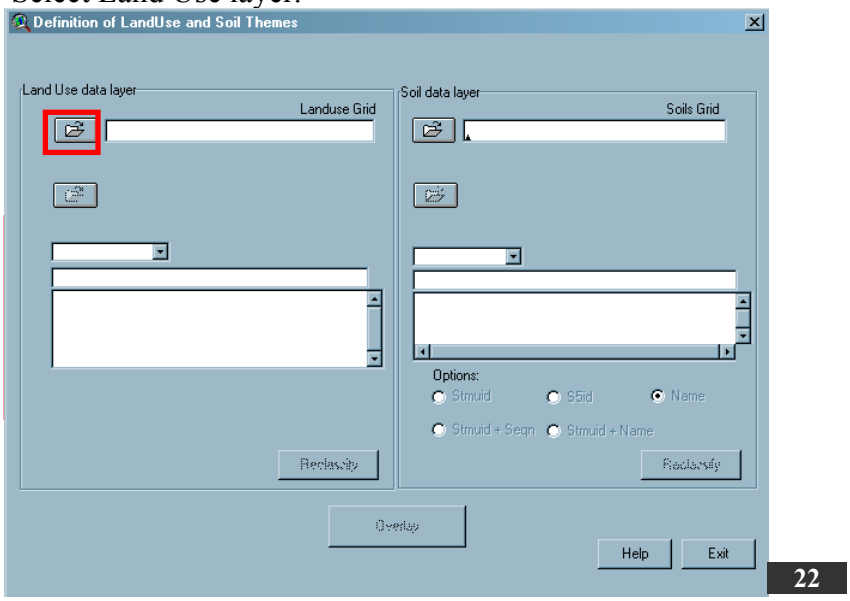
Step 11: After watersheds have been delineated, click **Apply** to calculate subbasin parameters.

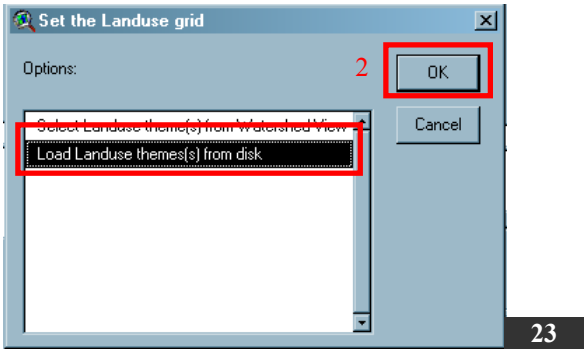


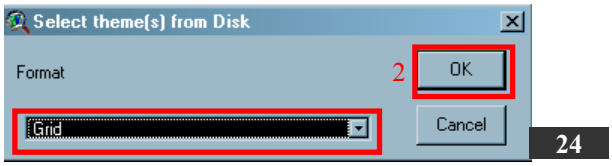
Step 12: From the AVSWAT menu, select **Land Use and Soil Definition**.

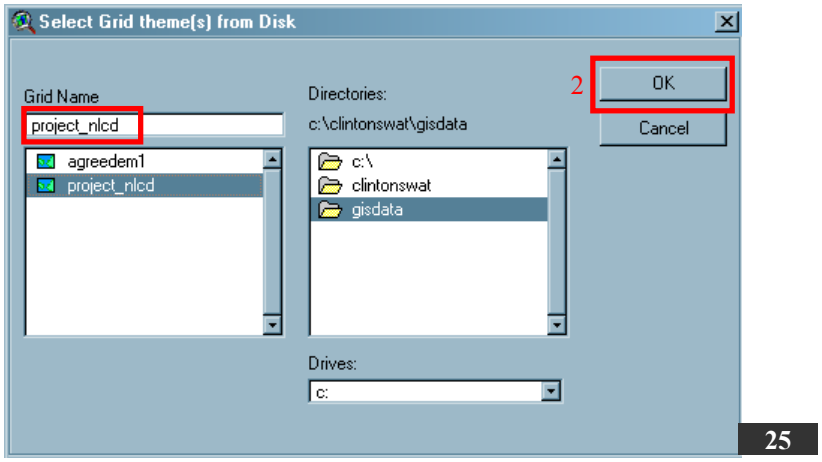


Step 13: Select Land Use layer.

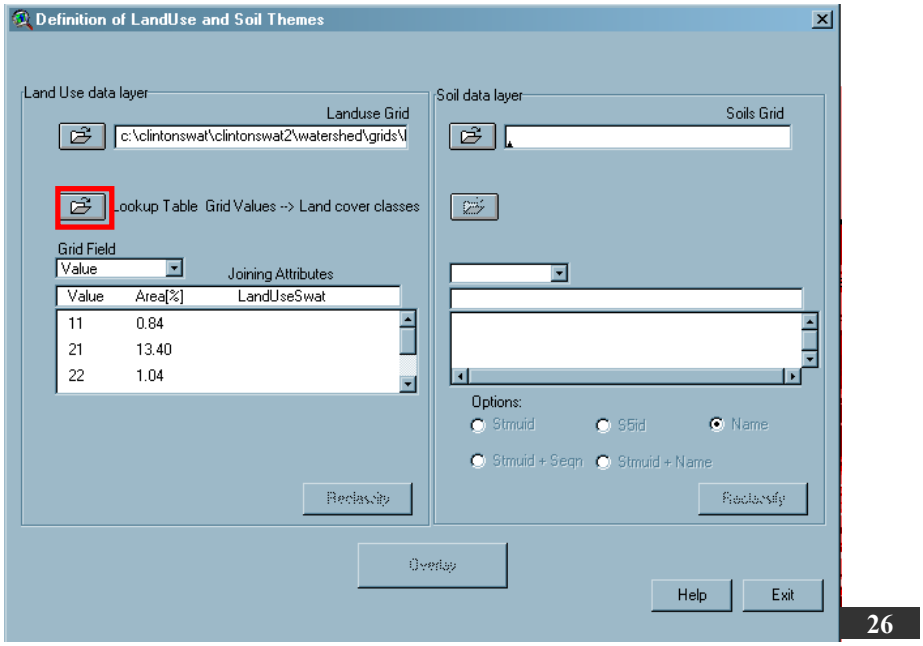


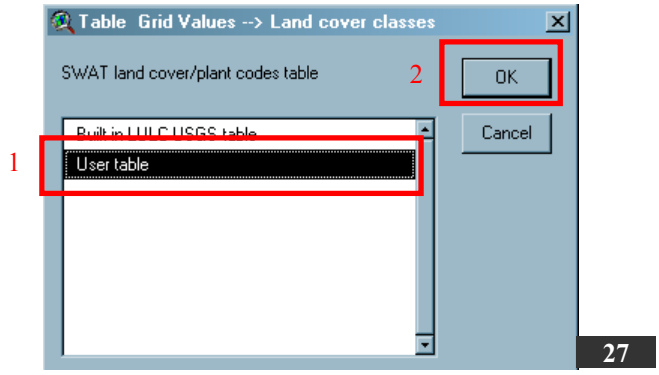


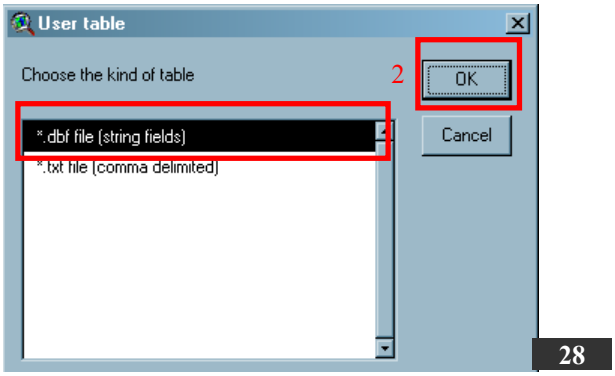


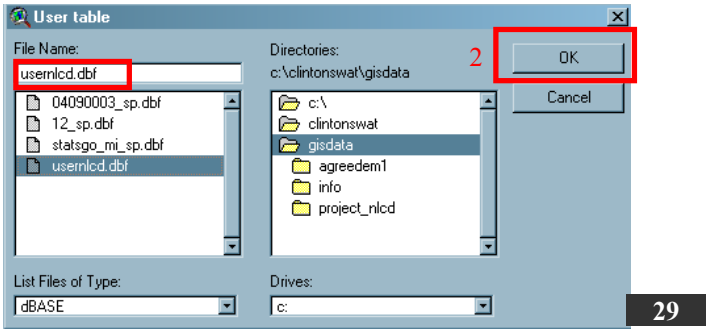


Step 14: Select land use lookup table and reclassify.









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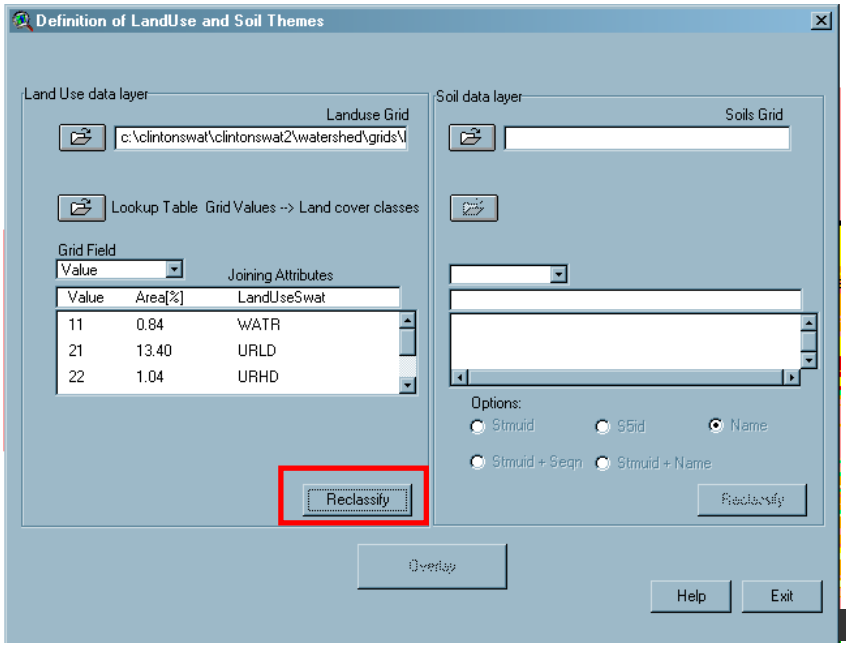

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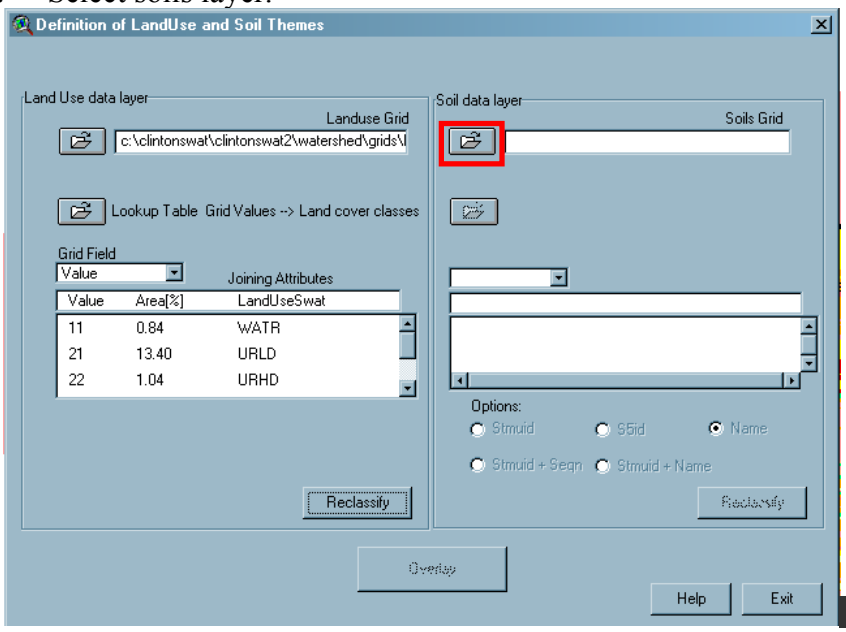
Step 15: Select soils layer.



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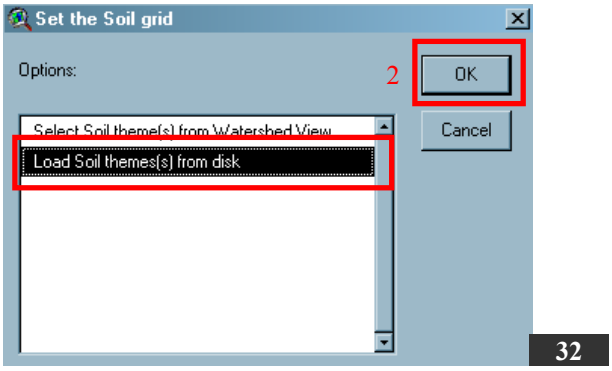
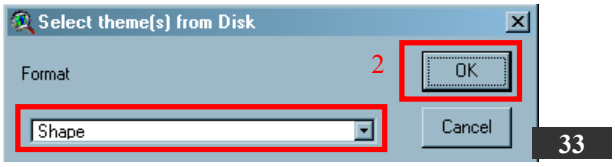
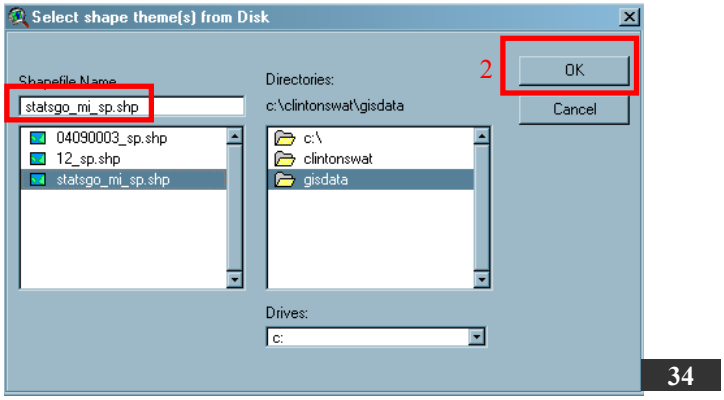
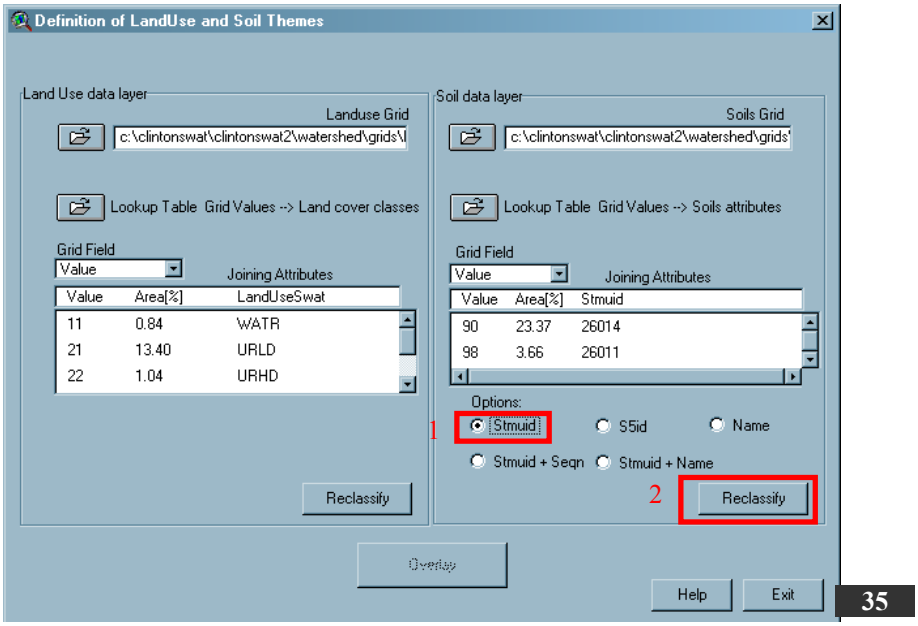
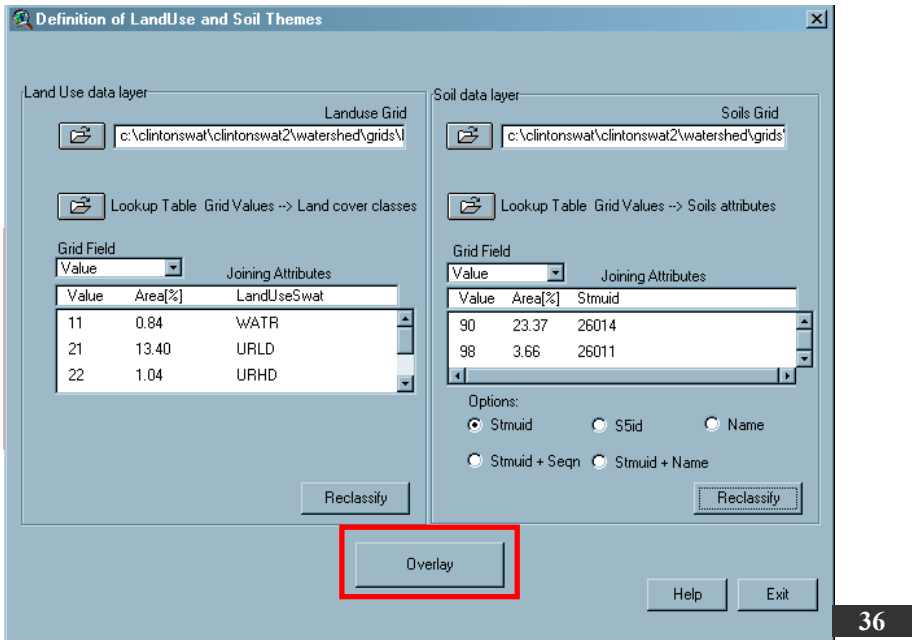

Set the Soil grid
Options:
2
OK
Cancel
Select Soil theme(s) from Watershed View
1
Load Soil theme(s) from disk
32

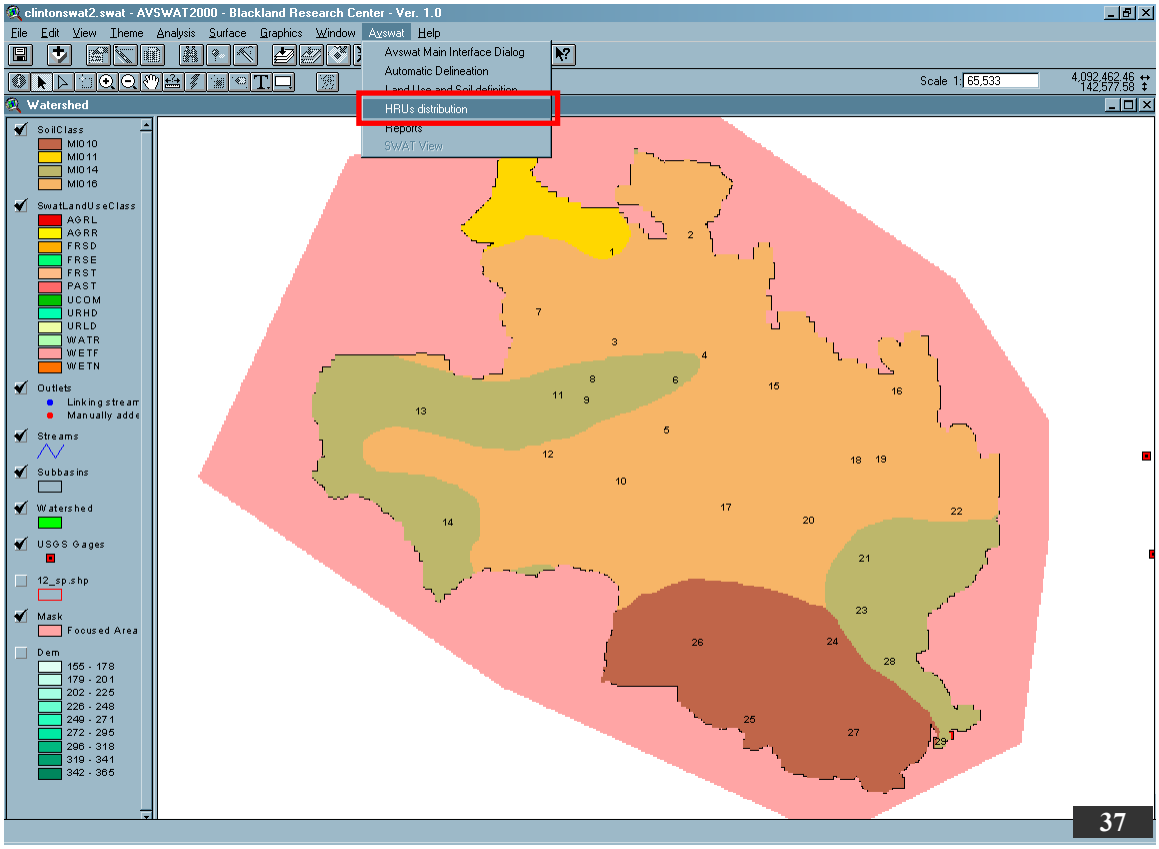

Select theme(s) from Disk
Format
2
OK
1
Shape
Cancel
33

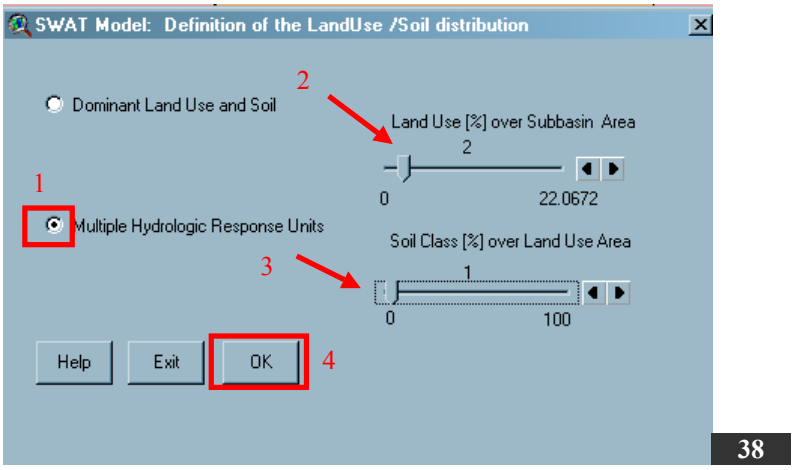

Select shape theme(s) from Disk
2
OK
Cancel
Shapefile Name
1
statsgo_mi_sp.shp
Directories:
c:\clintonswat\gisdata
04090003_sp.shp
12_sp.shp
statsgo_mi_sp.shp
c:\
clintonswat
gisdata
Drives:
c:
34


Definition of LandUse and Soil Themes
Land Use data layer
Landuse Grid
c:\clintonswat\clintonswat2\watershed\grids\l
Lookup Table Grid Values --> Land cover classes
Grid Field
Value
Joining Attributes
Value Area[%] LandUseSwat
11 0.84 WATR
21 13.40 URLD
22 1.04 URHD
Reclassify
Soil data layer
Soils Grid
c:\clintonswat\clintonswat2\watershed\grids
Lookup Table Grid Values --> Soils attributes
Grid Field
Value
Joining Attributes
Value Area[%] Stmuid
90 23.37 26014
98 3.66 26011
Options:
1
Stmuid
S5id
Name
Stmuid + Seqn
Stmuid + Name
2
Reclassify
Overlay
Help
Exit
35

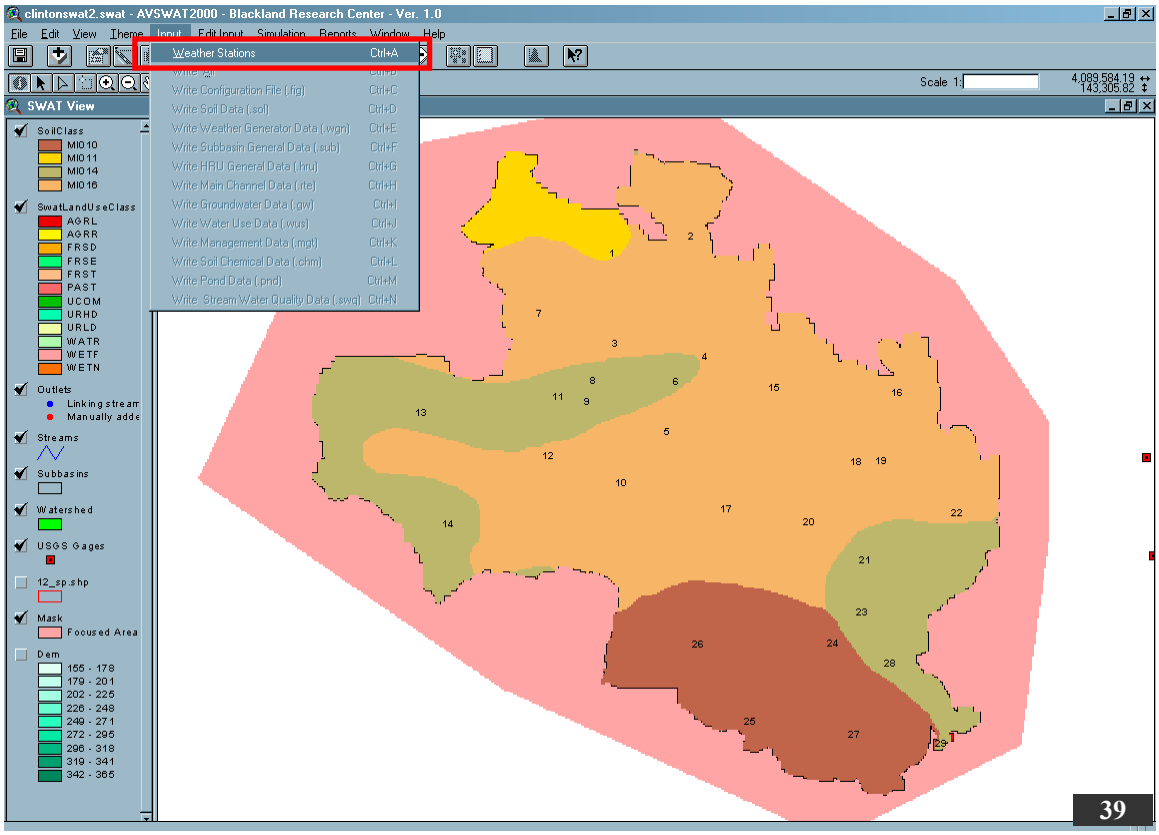


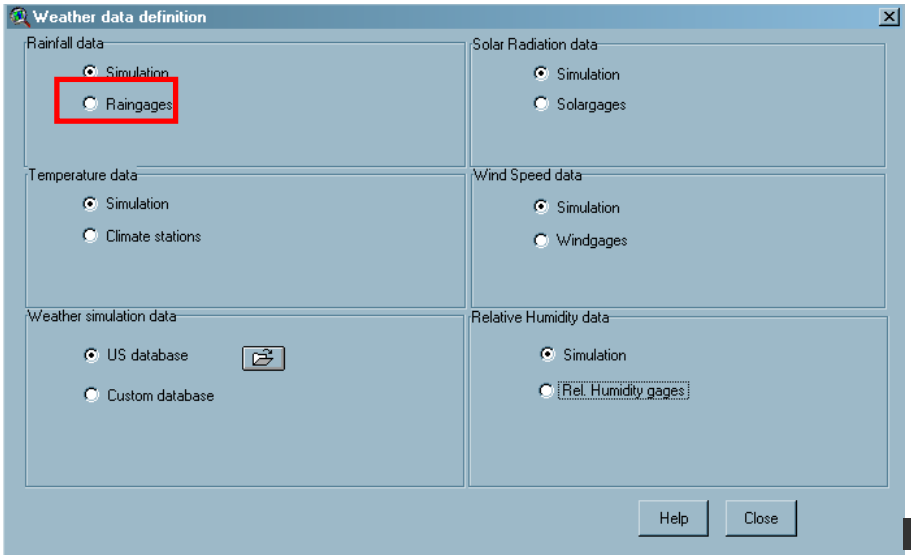
Step 16: Set HRU parameters.



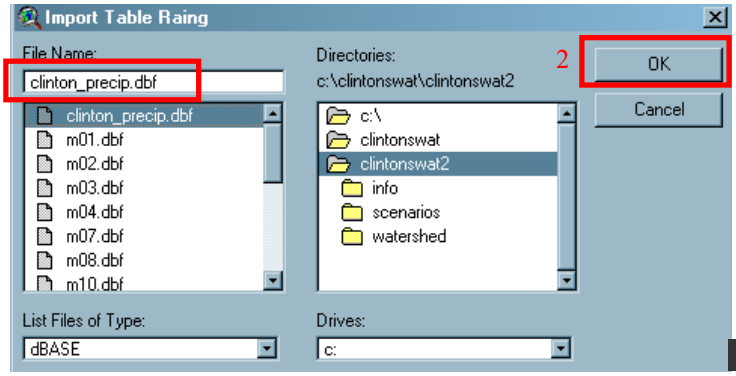


Step 17: Specify climate data.

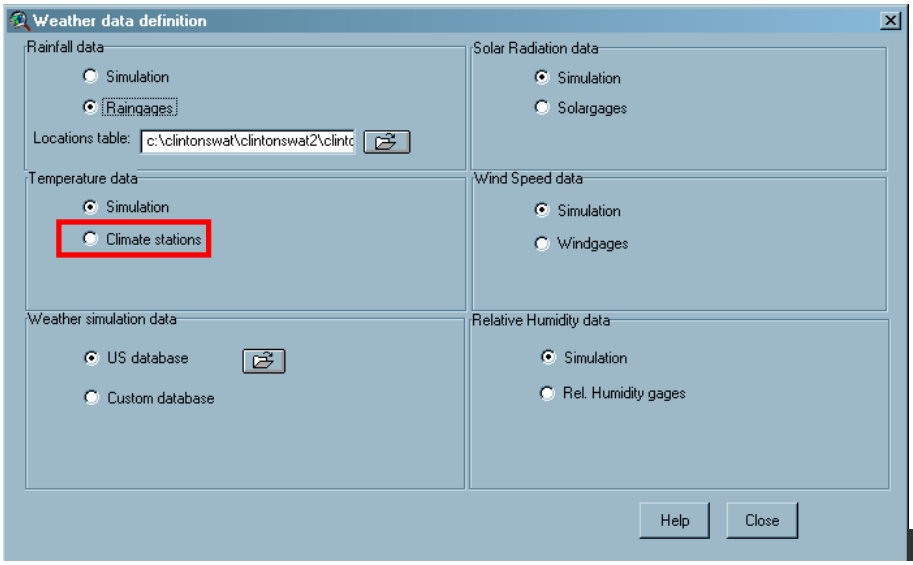



Weather data definition
Rainfall data
Simulation
Raingages
Solar Radiation data
Simulation
Solargages
Temperature data
Simulation
Climate stations
Wind Speed data
Simulation
Windgages
Weather simulation data
US database
Custom database
Relative Humidity data
Simulation
Rel. Humidity gages
Help
Close

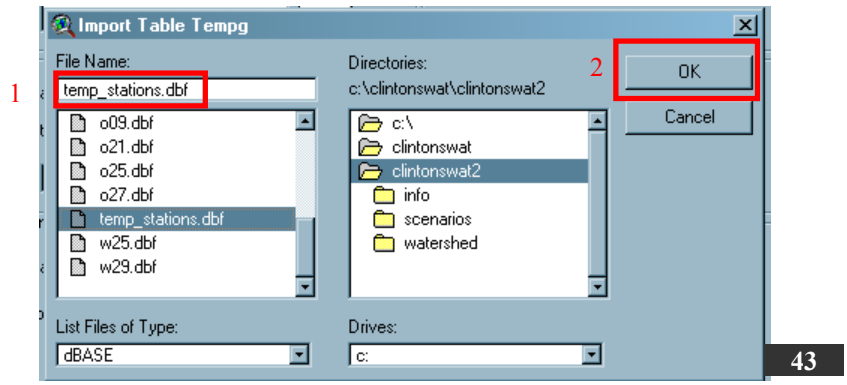
40

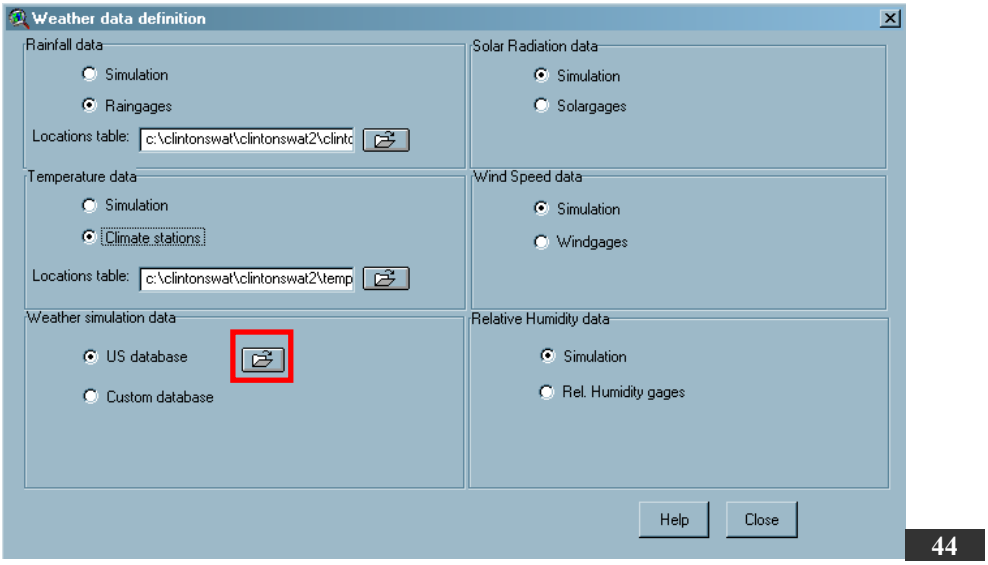

Import Table Raing
File Name:
clinton_precip.dbf
Directories:
c:\clintonswat\clintonswat2
1
2
OK
Cancel
clinton_precip.dbf
m01.dbf
m02.dbf
m03.dbf
m04.dbf
m07.dbf
m08.dbf
m10.dbf
c:\
clintonswat
clintonswat2
info
scenarios
watershed
List Files of Type:
dBASE
Drives:
c:

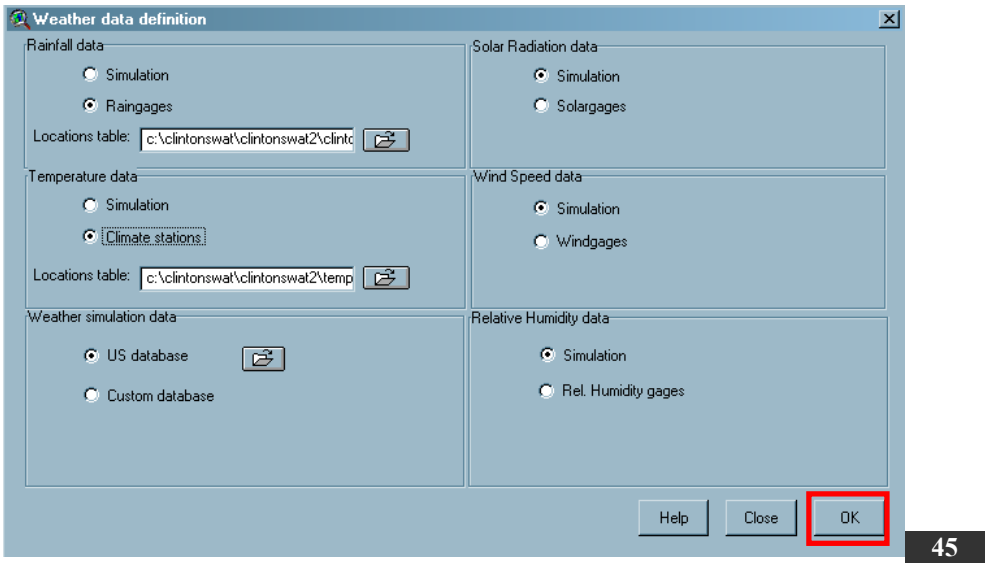
41


Weather data definition
Rainfall data
Simulation
Raingages
Locations table:
c:\clintonswat\clintonswat2\clint
Solar Radiation data
Simulation
Solargages
Temperature data
Simulation
Climate stations
Wind Speed data
Simulation
Windgages
Weather simulation data
US database
Custom database
Relative Humidity data
Simulation
Rel. Humidity gages
Help
Close

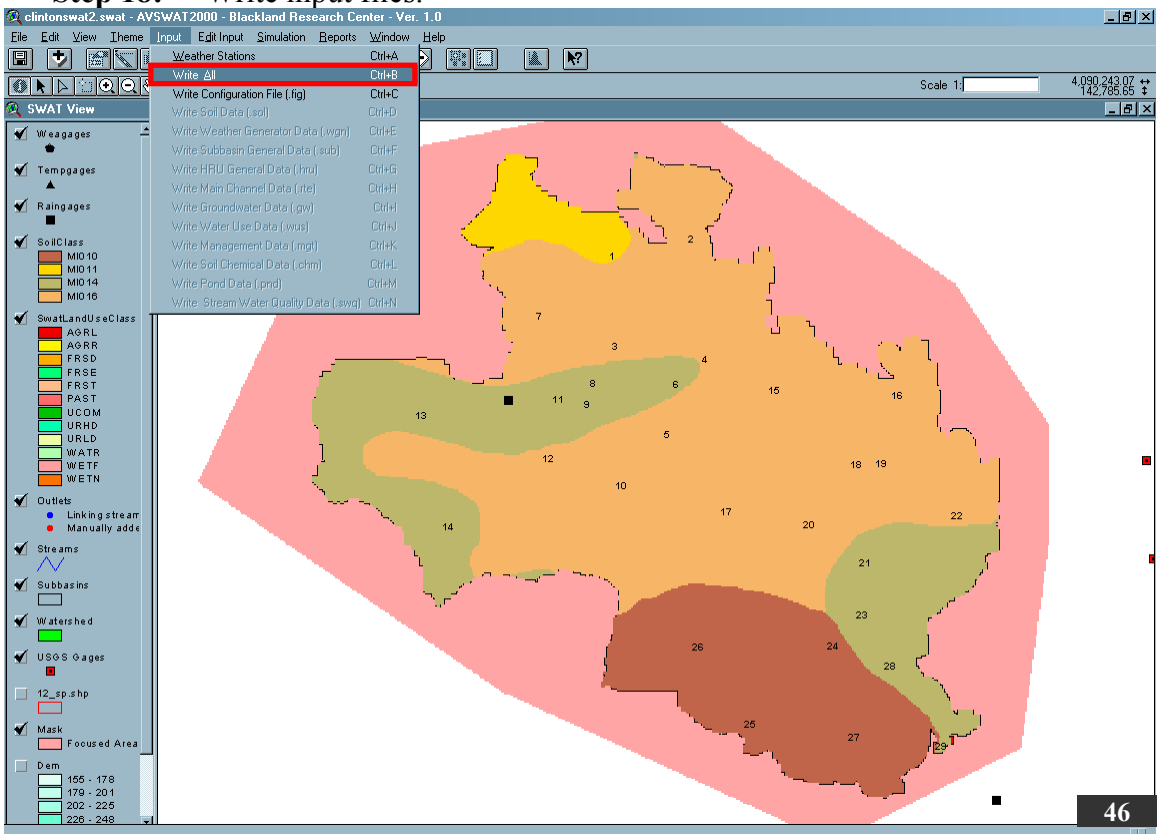
42

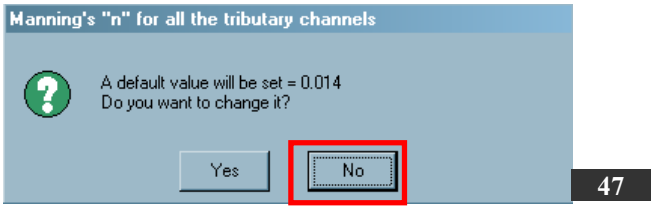

Import Table Tempg
File Name:
temp_stations.dbf
Directories:
c:\clintonswat\clintonswat2
OK
Cancel
o09.dbf
o21.dbf
o25.dbf
o27.dbf
temp_stations.dbf
w25.dbf
w29.dbf
c:\
clintonswat
clintonswat2
info
scenarios
watershed
List Files of Type:
dBASE
Drives:
c:
1
2
43

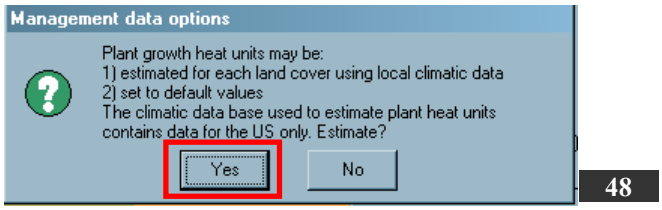

Weather data definition
Rainfall data
Simulation
Raingages
Locations table:
c:\clintonswat\clintonswat2\clintc
Solar Radiation data
Simulation
Solargages
Temperature data
Simulation
Climate stations
Locations table:
c:\clintonswat\clintonswat2\temp
Wind Speed data
Simulation
Windgages
Weather simulation data
US database
Custom database
Relative Humidity data
Simulation
Rel. Humidity gages
Help
Close
44


Weather data definition
Rainfall data
Simulation
Raingages
Locations table:
c:\clintonswat\clintonswat2\clintc
Solar Radiation data
Simulation
Solargages
Temperature data
Simulation
Climate stations
Locations table:
c:\clintonswat\clintonswat2\temp
Wind Speed data
Simulation
Windgages
Weather simulation data
US database
Custom database
Relative Humidity data
Simulation
Rel. Humidity gages
Help
Close
OK
45

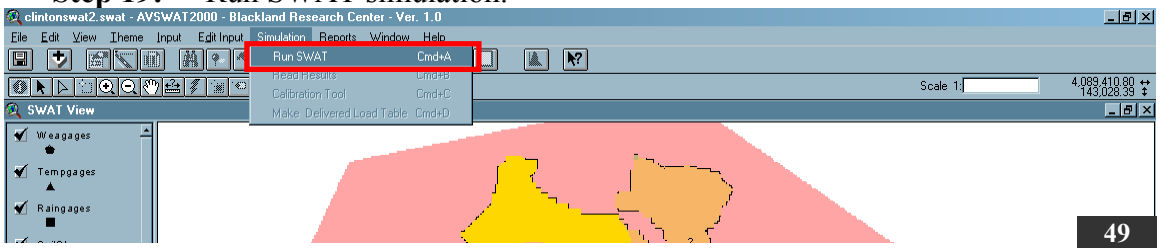
Step 18: Write input files.

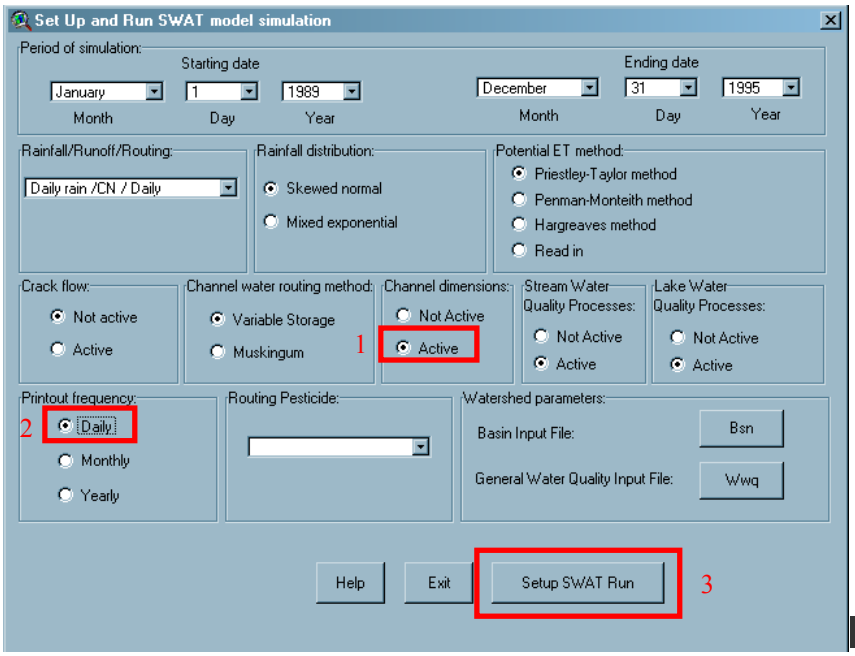




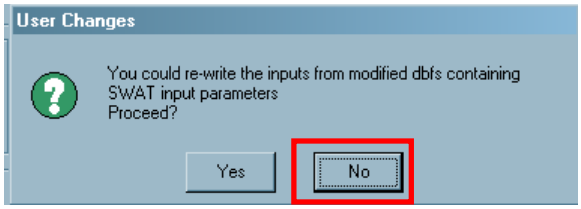

Management data options
Plant growth heat units may be:
1) estimated for each land cover using local climatic data
2) set to default values
The climatic data base used to estimate plant heat units
contains data for the US only. Estimate?
Yes
No
48

Step 19: Run SWAT simulation.

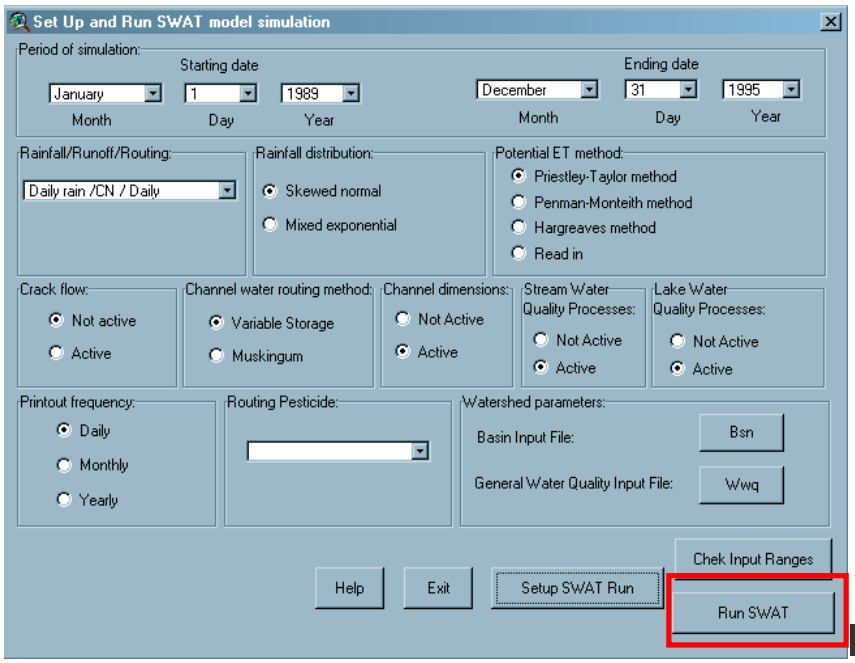



Set Up and Run SWAT model simulation
Period of simulation:
Starting date
January
1
1989
Month
Day
Year
Ending date
December
31
1995
Month
Day
Year
Rainfall/Runoff/Routing:
Daily rain /CN / Daily
Rainfall distribution:
Skewed normal
Mixed exponential
Potential ET method:
Priestley-Taylor method
Penman-Monteith method
Hargreaves method
Read in
Crack flow:
Not active
Active
Channel water routing method:
Variable Storage
Muskingum
Channel dimensions:
Not Active
Active
1
Stream Water Quality Processes:
Not Active
Active
Lake Water Quality Processes:
Not Active
Active
Printout frequency:
2
Daily
Monthly
Yearly
Routing Pesticide:
Watershed parameters:
Basin Input File:
Bsn
General Water Quality Input File:
Wwq
Help
Exit
Setup SWAT Run
3

50


User Changes
You could re-write the inputs from modified dbfs containing
SWAT input parameters
Proceed?
Yes
No

51


Set Up and Run SWAT model simulation
Period of simulation:
Starting date
January
1
1989
Month
Day
Year
Ending date
December
31
1995
Month
Day
Year
Rainfall/Runoff/Routing:
Daily rain /CN / Daily
Rainfall distribution:
Skewed normal
Mixed exponential
Potential ET method:
Priestley-Taylor method
Penman-Monteith method
Hargreaves method
Read in
Crack flow:
Not active
Active
Channel water routing method:
Variable Storage
Muskingum
Channel dimensions:
Not Active
Active
Stream Water Quality Processes:
Not Active
Active
Lake Water Quality Processes:
Not Active
Active
Printout frequency:
Daily
Monthly
Yearly
Routing Pesticide:
Watershed parameters:
Basin Input File:
Bsn
General Water Quality Input File:
Wwq
Chek Input Ranges
Help
Exit
Setup SWAT Run
Run SWAT

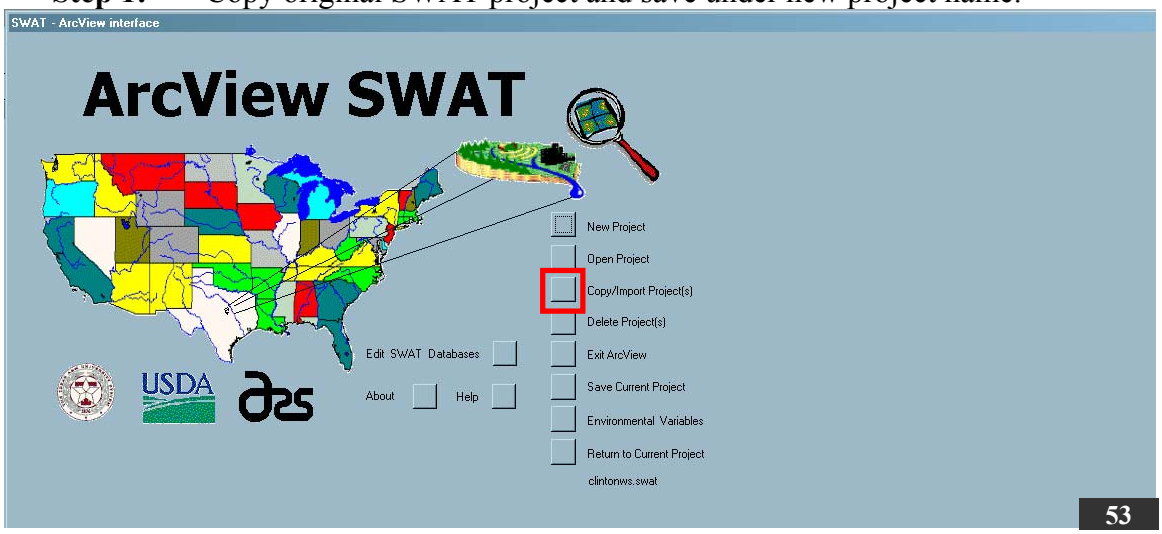
52

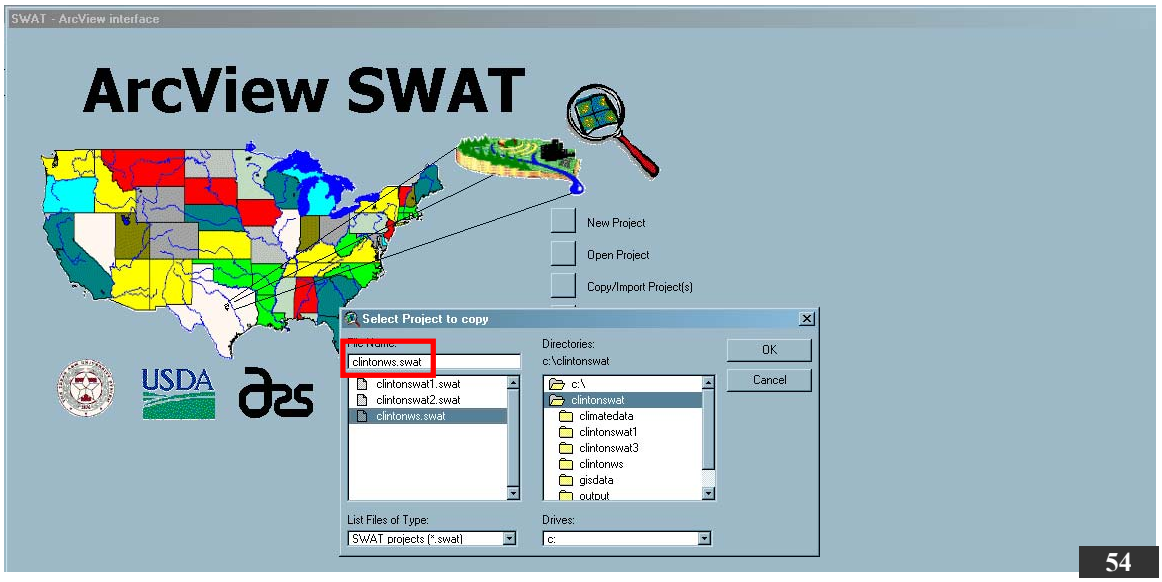
2.5 Change Land Use Tutorial

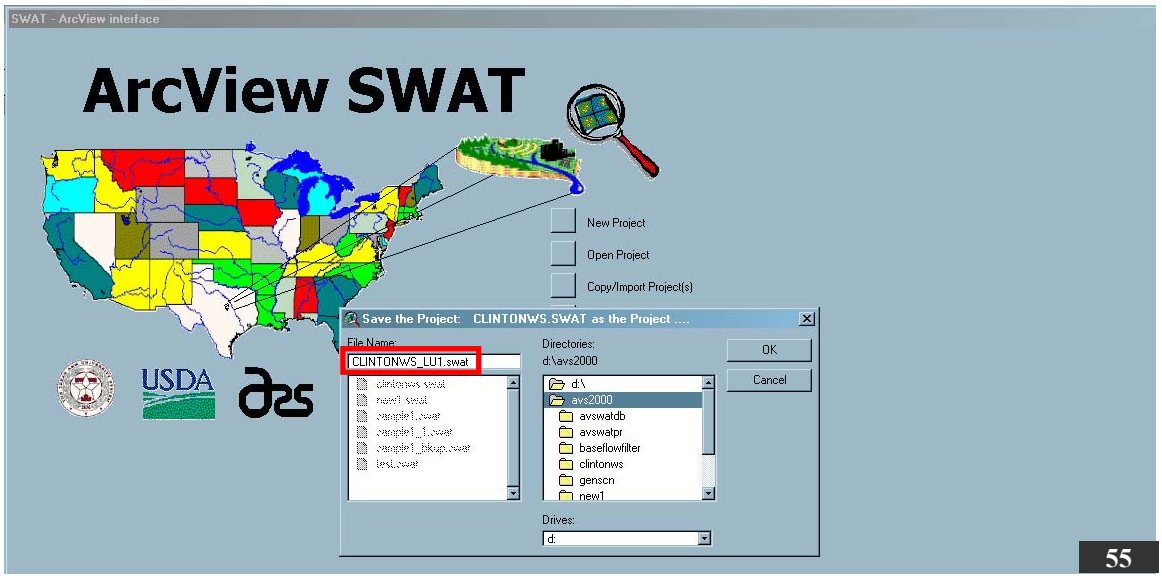
The following tutorial shows how to change the land use in the Clinton SWAT model and see how the watershed reacts to the change.

The red boxes on the following screen images show where the user needs to click or type; the yellow boxes are to draw the users attention (no action is required); and the red numbers indicate the order in which the actions need to occur.

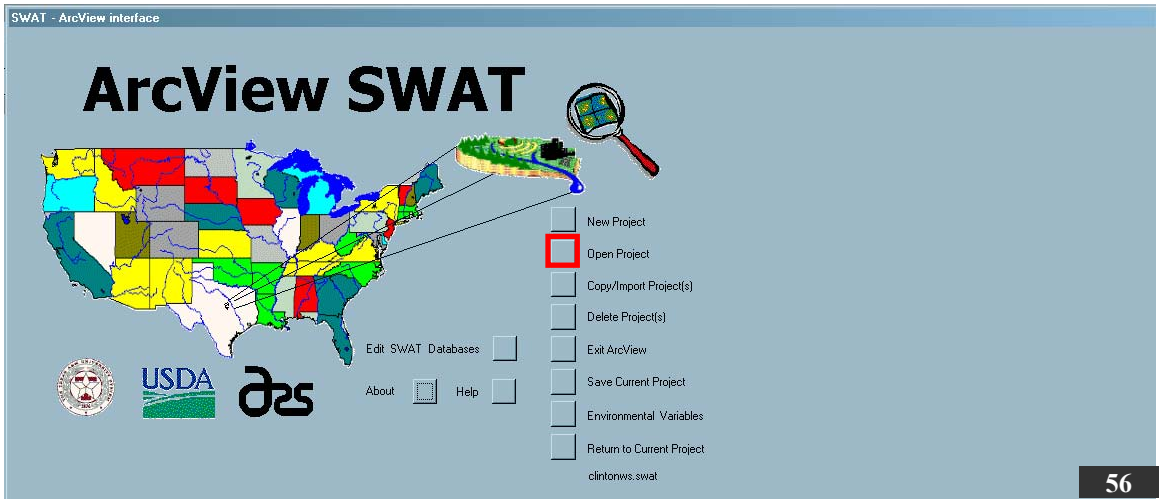
Step 1: Copy original SWAT project and save under new project name.

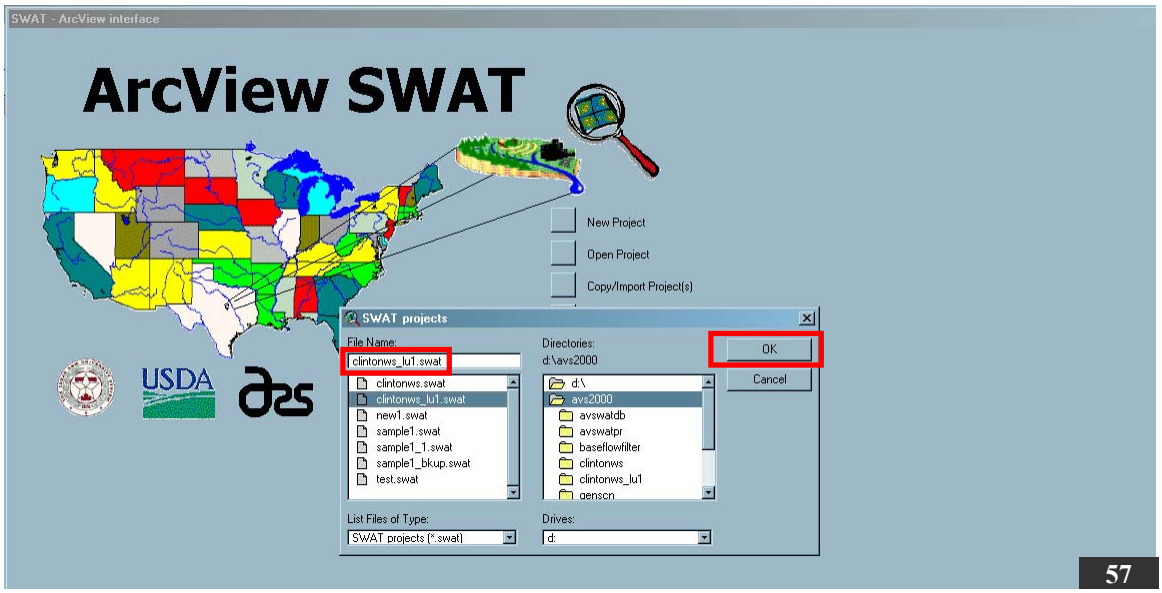


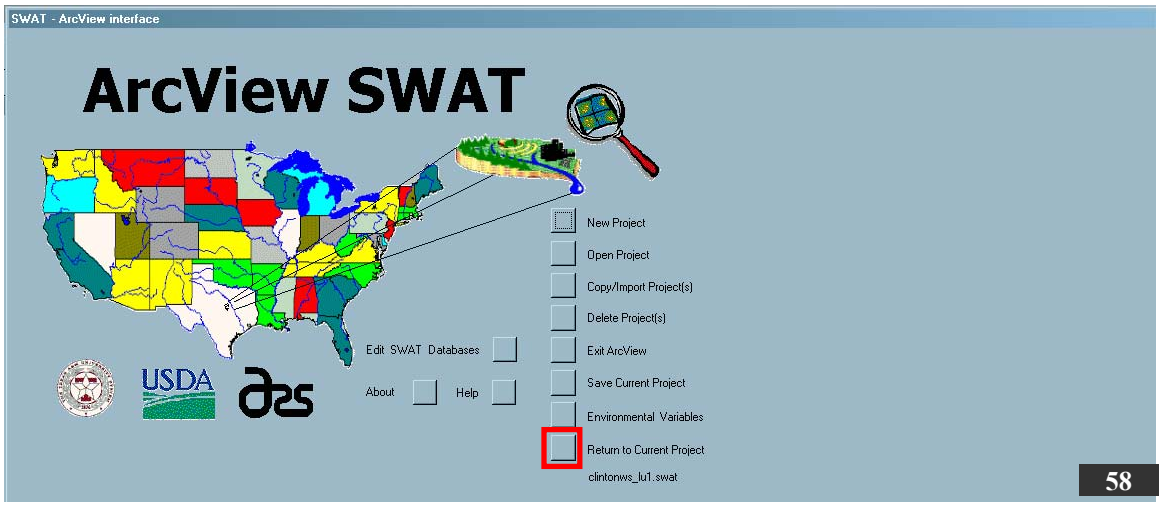




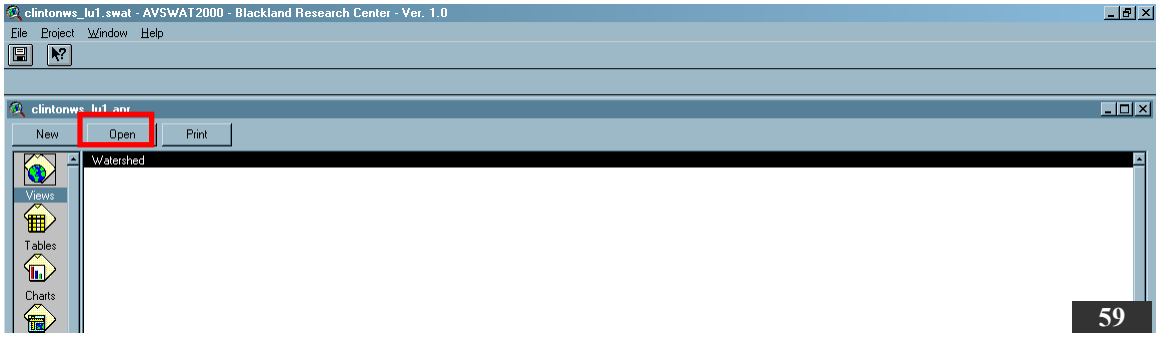
Step 2: When the copy process is finished, click Open Project to open the newly created project.







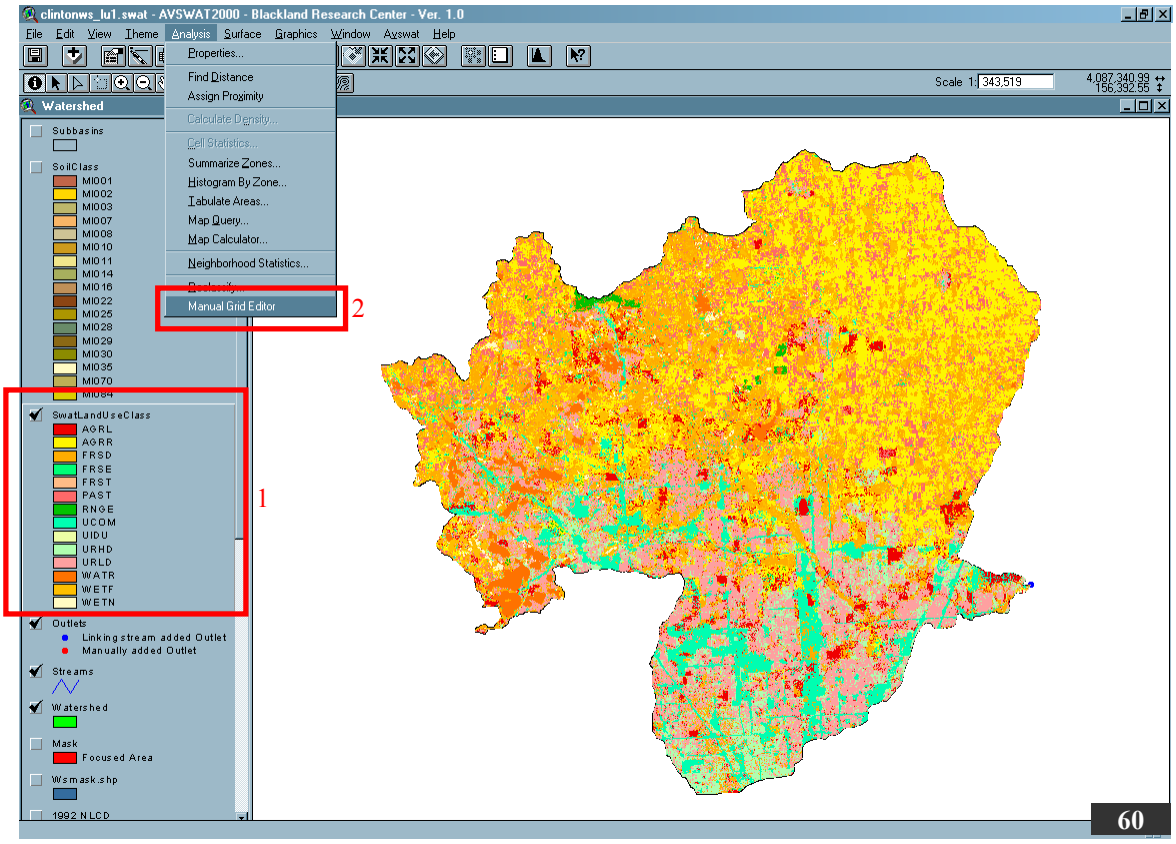
Step 3: Open the "Watershed" view.



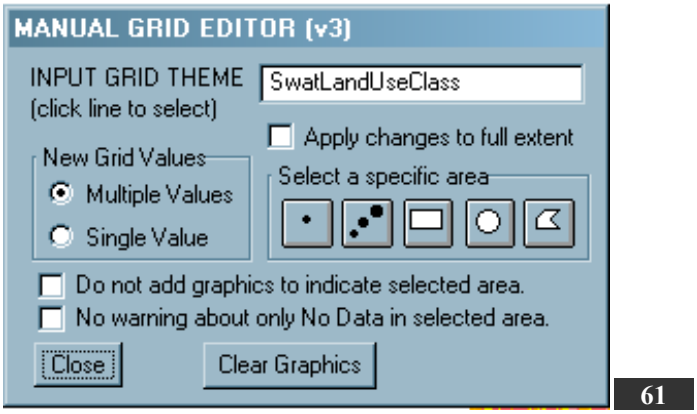
The next step is to modify the original land use used for the SWAT model or create/import a new land use coverage (e.g., a future land use coverage). For this

exercise, the SWAT Land Use grid will be modified using an ArcView extension called "Manual Grid Editor". Refer to Appendix UM2 for instructions on how to install this ArcView extension.

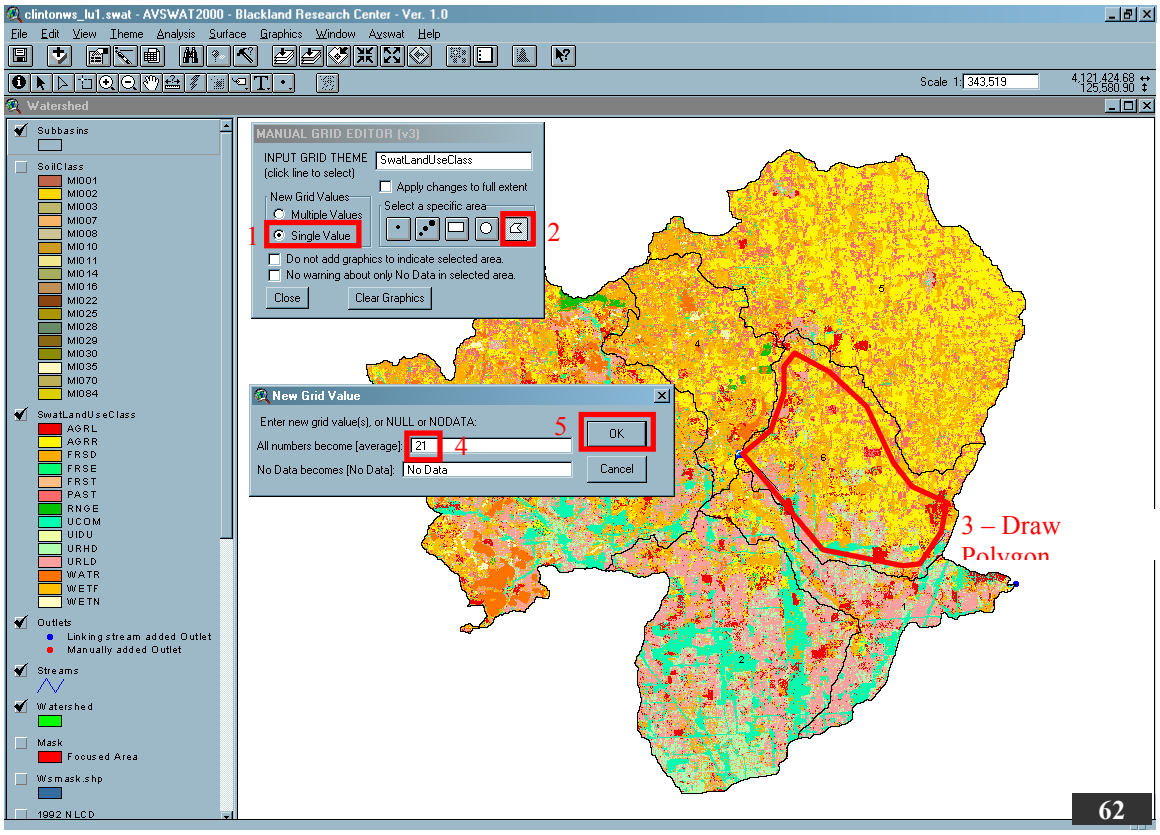
Step 4: Make the SWAT Land Use grid active and open the Manual Grid Editor.

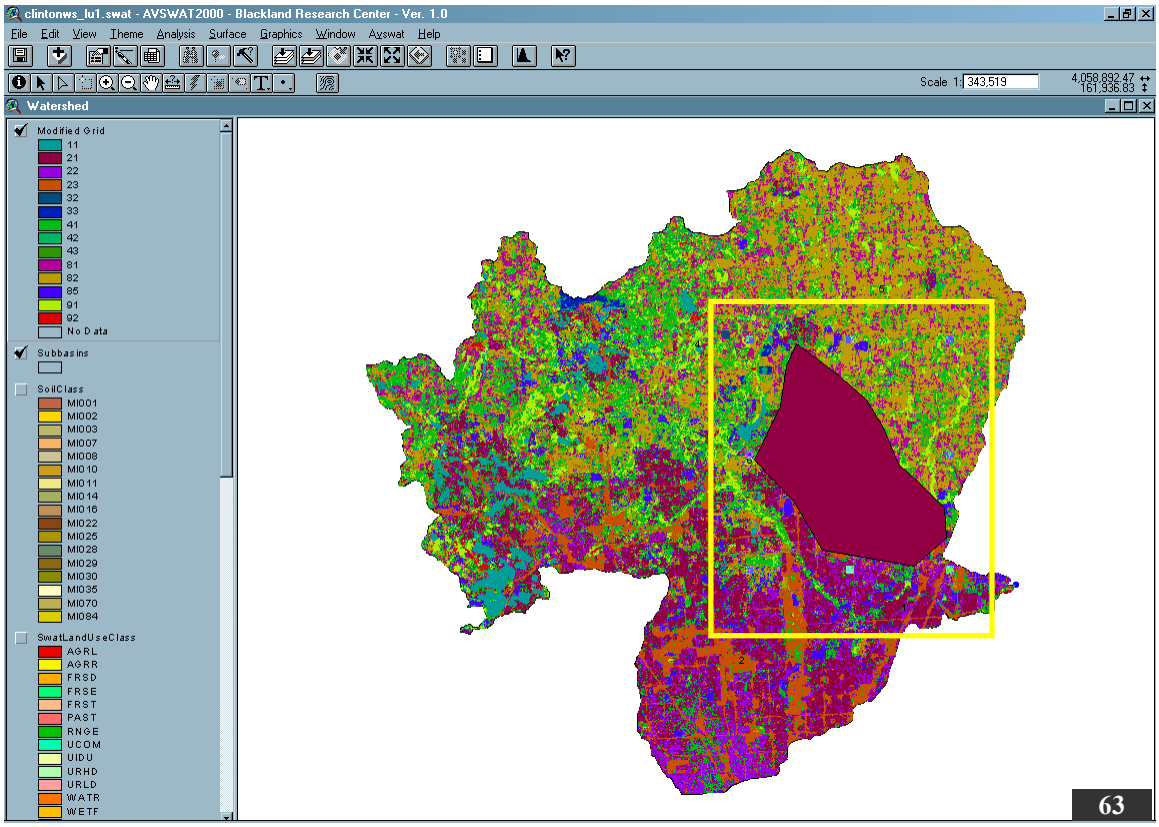


Step 5: Select area of land use grid to modify. The Manual Grid Editor allows the user to modify the whole grid or just a portion (using the graphics tools) and to change the selected area to multiple land use values or one single value.

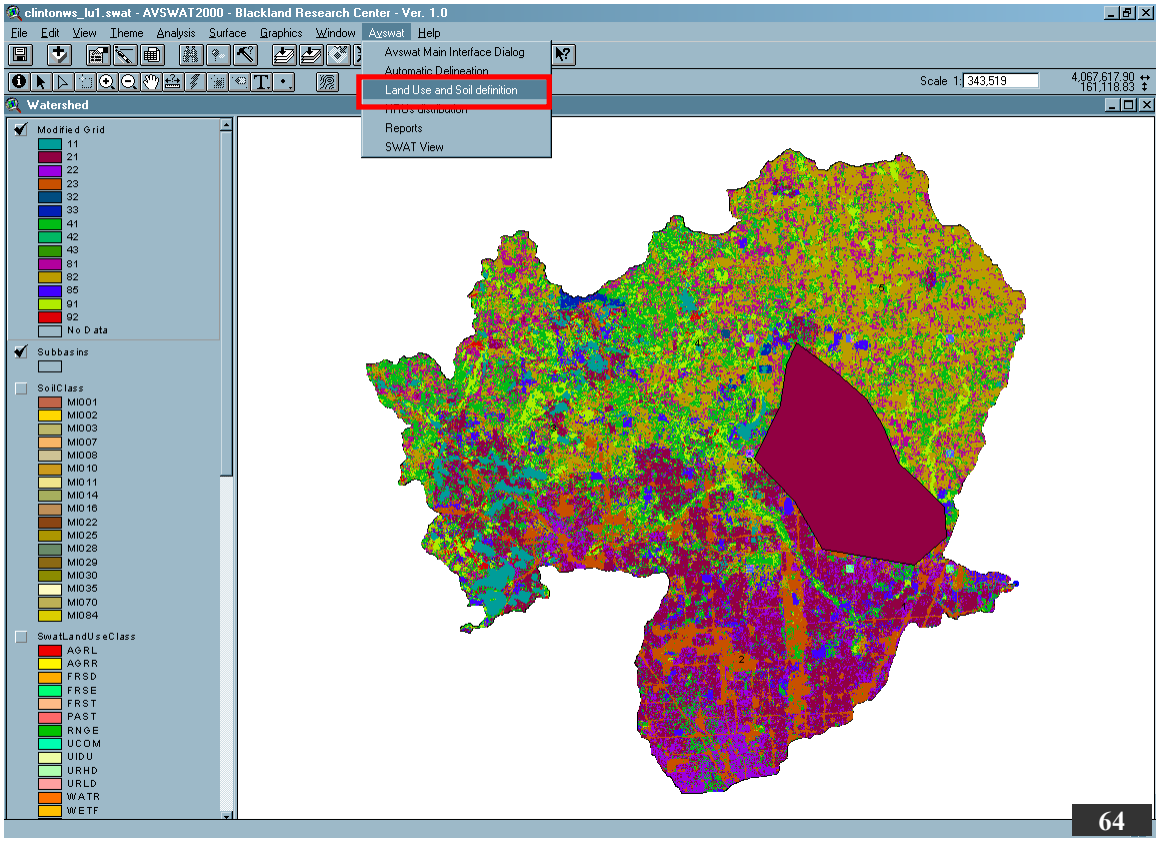


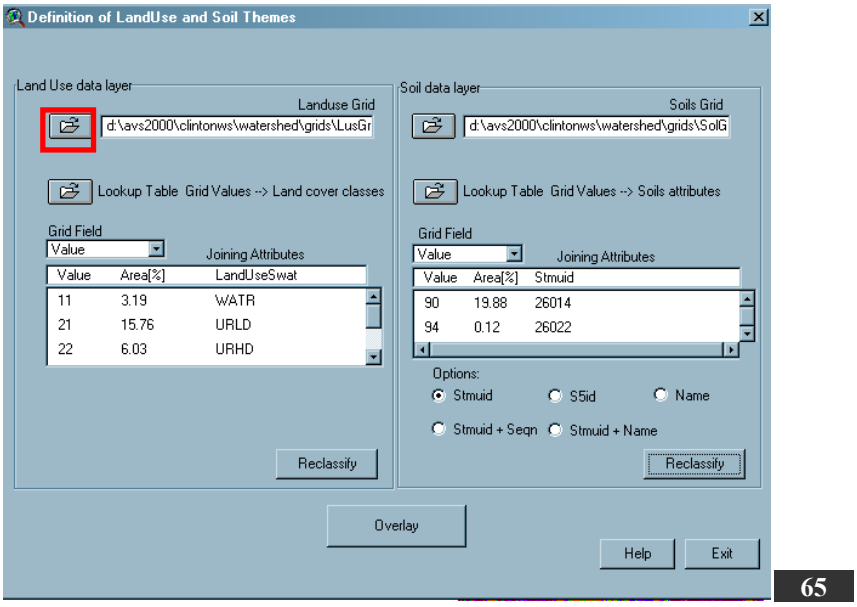
For this example a polygon will be used to change the land use in the selected area to low intensity residential (grid code = 21). The first click will initiate the polygon, and to complete the polygon, hold down the "Ctrl" key while clicking the final point or double-click on the final point.

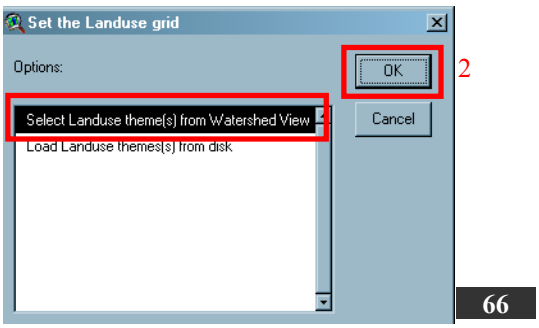


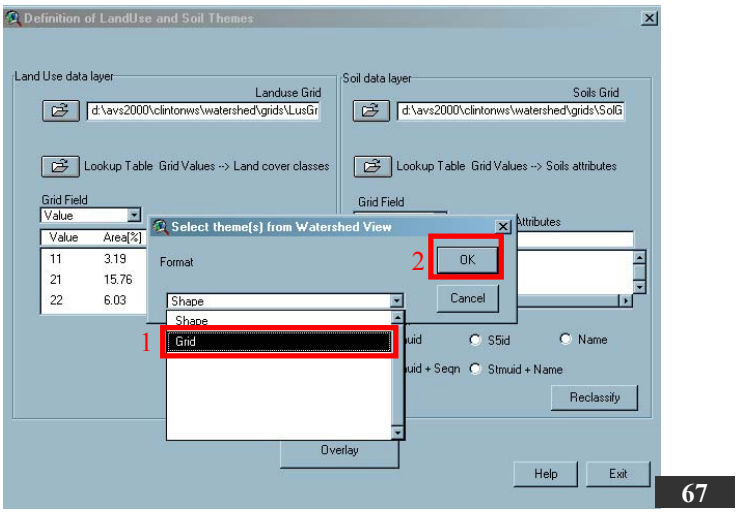


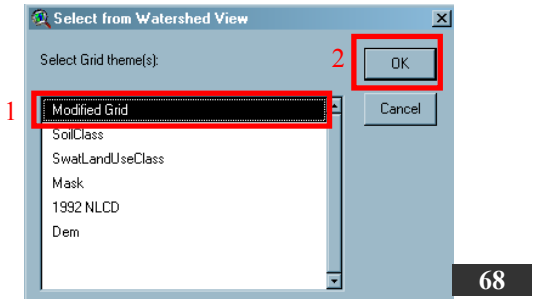
Step 6: Select newly modified land use grid ("Modified Grid") for use in SWAT model.

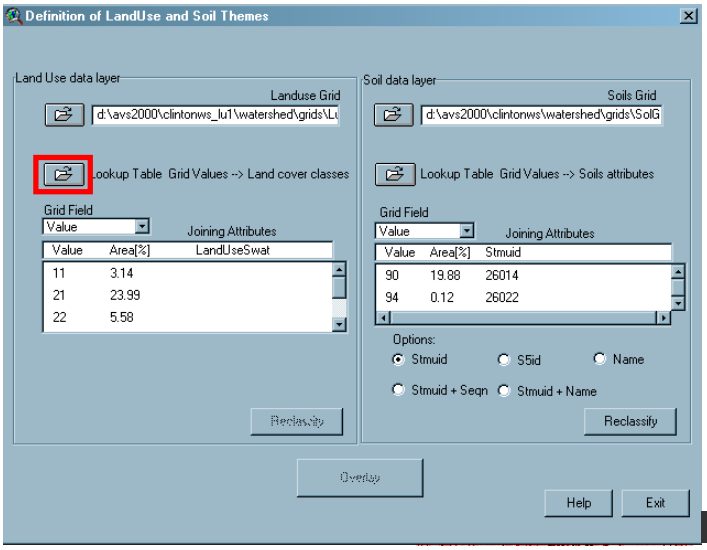

clintonws_lu1.swat - AVSWAT2000 - Blackland Research Center - Ver. 1.0
File Edit View Theme Analysis Surface Graphics Window Avswat Help
Avswat Main Interface Dialog
Automatic Delineation
Land Use and Soil definition
Reports
SWAT View
Scale 1: 343,519
Watershed
Modified Grid
11
21
22
23
32
33
41
42
43
81
82
85
91
92
No Data
Subbasins
SoilClass
MI001
MI002
MI003
MI007
MI008
MI010
MI011
MI014
MI016
MI022
MI025
MI028
MI029
MI030
MI035
MI070
MI084
SwatLandUseClass
AGRL
AGRR
FRSD
FRSE
FRST
PAST
RNGE
UCOM
UIDU
URHD
URLD
WATR
WETF
64


Definition of LandUse and Soil Themes
Land Use data layer
Landuse Grid
d:\avs2000\clintonws\watershed\grids\LusGr
Lookup Table Grid Values --> Land cover classes
Grid Field
Value
Joining Attributes
Value Area[%] LandUseSwat
11 3.19 WATR
21 15.76 URLD
22 6.03 URHD
Reclassify
Soil data layer
Soils Grid
d:\avs2000\clintonws\watershed\grids\SolG
Lookup Table Grid Values --> Soils attributes
Grid Field
Value
Joining Attributes
Value Area[%] Stmuid
90 19.88 26014
94 0.12 26022
Options:
Stmuid
S5id
Name
Stmuid + Seqn
Stmuid + Name
Reclassify
Overlay
Help
Exit
65


Set the Landuse grid
Options:
OK
2
1
Select Landuse theme(s) from Watershed View
Cancel
Load Landuse themes(s) from disk
66


Definition of LandUse and Soil Themes
Land Use data layer
Landuse Grid
d:\avs2000\clintonws\watershed\grids\LusGr
Lookup Table Grid Values --> Land cover classes
Grid Field
Value
Value Area[%]
11 3.19
21 15.76
22 6.03
Soil data layer
Soils Grid
d:\avs2000\clintonws\watershed\grids\SolG
Lookup Table Grid Values --> Soils attributes
Grid Field
Attributes
Select theme(s) from Watershed View
Format
2
OK
Cancel
Shape
Shape
1
Grid
S5id
Name
Stmuid + Name
Reclassify
Overlay
Help
Exit
67


Select from Watershed View
Select Grid theme(s):
2
OK
1
Modified Grid
Cancel
SoilClass
SwatLandUseClass
Mask
1992 NLCD
Dem
68


Definition of LandUse and Soil Themes
Land Use data layer
Landuse Grid
d:\avs2000\clintonws_lu1\watershed\grids\Lt
Lookup Table Grid Values --> Land cover classes
Grid Field
Value
Joining Attributes
Value Area[%] LandUseSwat
11 3.14
21 23.99
22 5.58
Reclassify
Soil data layer
Soils Grid
d:\avs2000\clintonws\watershed\grids\SoilG
Lookup Table Grid Values --> Soils attributes
Grid Field
Value
Joining Attributes
Value Area[%] Stmuid
90 19.88 26014
94 0.12 26022
Options:
Stmuid
S5id
Name
Stmuid + Seqn
Stmuid + Name
Reclassify
Overlay
Help
Exit
69

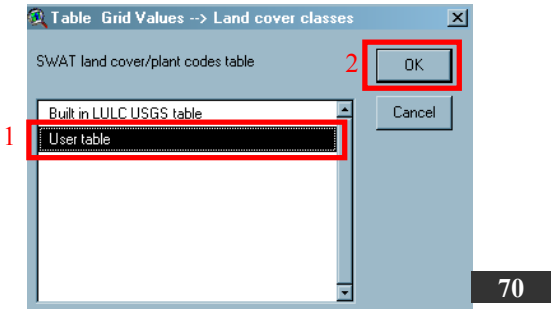
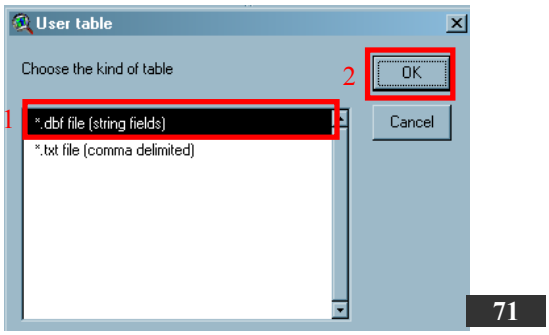
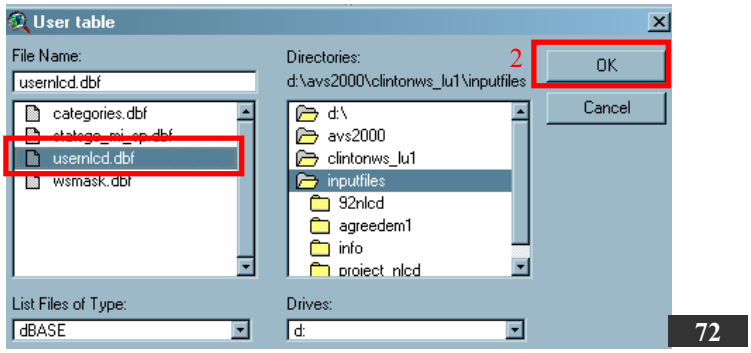
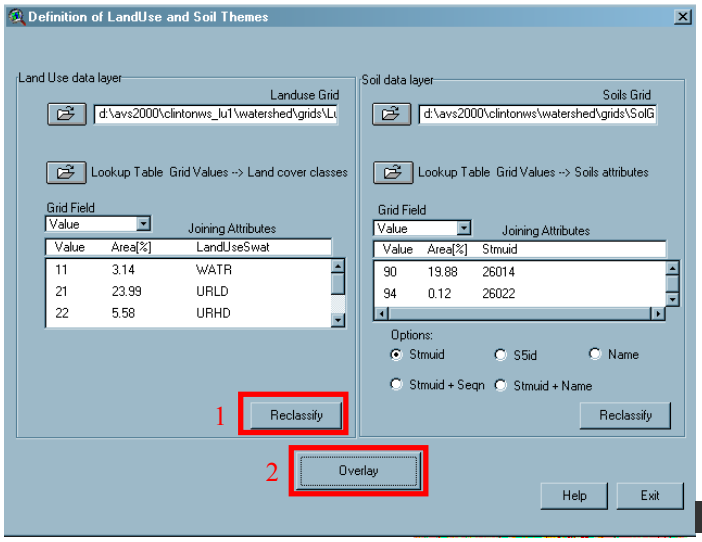


Table Grid Values --> Land cover classes
SWAT land cover/plant codes table
2
OK
Cancel
Built in LULC USGS table
1
User table
70


User table
Choose the kind of table
2
OK
1
*.dbf file (string fields)
*.txt file (comma delimited)
Cancel
71


User table
File Name:
usernlcd.dbf
Directories:
d:\avs2000\clintonws_lu1\inputfiles
2
OK
Cancel
categories.dbf
1
usernlcd.dbf
wsmask.dbf
d:\
avs2000
clintonws_lu1
inputfiles
92nlcd
agreedem1
info
List Files of Type:
dBASE
Drives:
d:
72



Step 7: Proceed with SWAT setup and run model.

2.6 Clinton SWAT Model Calibration Parameters

Table 2.2 lists the calibration parameter adjustments used for the entire Clinton River Watershed SWAT model for 1992 land use. Refer to Section 13.3 of the AVSWAT User's Guide for information regarding the AVSWAT Calibration Tool.

Table 2.2 Calibration parameters for Clinton SWAT model.

Calibration Parameter	*Adjustment*
CN2	-4
ALPHA_BF	+0.5
ESCO	+0.95
REVAPMN	+50

2.7 Land Management Practices in SWAT

- Tillage operations – refer to Technical Documentation (TD) 20.6
  - Tillage operation redistributes residue, nutrients, pesticides and bacteria in the soil profile.
  - User has the option of varying the curve number in the HRU throughout the year.
  - From Table 4 in Kirsch, et al. (2002)

Transect Survey Residue	*Assumed SWAT Tillage Practice*
Conventional (<15% cover)	Moldboard plow
Other (15% to 30% cover)	2 passes with chisel plow
Mulch (>30% cover)	1 pass with chisel plow
No-till	No-till

- Filter strips – refer to TD 20.10

    - Edge-of field filter strips may be defined in an HRU.
    - Sediment, nutrient, pesticide and bacteria loads in surface runoff are reduced as the surface runoff passes through the filter strip.
- Riparian buffer areas – refer to Vaché, et al. (2002)
    - Adjust channel cover factor and channel erodibility factor.
- Irrigation – refer to TD 21.1
    - Irrigation in an HRU may be scheduled by the user or automatically applied by SWAT.
    - In addition to specifying the timing and application amount, the user must specify the source of irrigation water.
- Infiltration – refer to TD 22.1 & 22.2
    - User can specify fraction of impervious area, fraction of directly connected impervious area and curve number for urban land types.
    - Hydraulic conductivity can also be altered.
    - Use Green & Ampt method and sub-daily precipitation to directly model infiltration.
- Street sweeping in urban areas – refer to TD 22.4.1
    - Sweep operations impact build up of solids in the impervious portion of the HRU.
    - SWAT performs street sweeping operations only when the build up/wash off algorithm is specified for urban loading calculations.
    -

2.8 SWAT Output Description

Every SWAT simulation generates a number of output files including:

- The summary output file (output.std),
- The HRU output file (.sbs),
- The subbasin output file (.bsb) and
- The main channel or reach output file (.rch)

These are ASCII text files that can be viewed using any text editor. These files (excluding output.std) can also be imported into ArcView. After the SWAT model is run, a dialog box will appear asking if the user wants to read the ASCII outputs. If "yes" is selected, AVSWAT will create .dbf table files from the ASCII text outputs, import them into the ArcView project and open them. The user then has the option to use the **Map-Chart** tool under the **Reports** menu to plot the SWAT results.

Chapter 32 of the SWAT User's Manual (Neitsch, 2002a) explains in detail the primary output files and the information they contain. Descriptions of the most relevant output variables for the Clinton River SWAT model are described below.

Subbasin Output File (basins.bsb)

This file contains summary information for each subbasin in the watershed.

Variable Name	Description
PRECIP	Total amount of precipitation falling on the subbasin during a time step (mm H_2O).
SURQ	Surface runoff contribution to streamflow during a time step (mm H_2O).
GW_Q	Groundwater contribution to streamflow (mm). Water from the shallow aquifer that returns to the reach during a time step.
WYLD	Water yield (mm H_2O). The net amount of water that leaves the subbasin and contributes to streamflow in the reach during a time step.
SYLD	Sediment yield (metric tons/ha). Sediment from the subbasin that is transported into the reach during a time step.

Main Channel Output File (basins.rch)

This file contains summary information for each routing reach in the watershed.

Variable Name	Description
FLOW_IN	Average daily streamflow into reach during a time step (m^3/s).
FLOW_OUT	Average daily streamflow out of reach during a time step (m^3/s).
SED_IN	Sediment transported with water into reach during a time step (metric tons).
SED_OUT	Sediment transported with water out of reach during a time step (metric tons).
SEDCONC	Concentration of sediment in reach during a time step (mg/L).

2.9 Future Developments

An ArcView 8.x interface for SWAT is currently under development by Francisco Olivera and others at Texas A&M University. It is compatible with the ArcHydro data model, a standard data model for spatial and temporal hydrologic data, thus enabling more integration with other hydrologic and hydraulic models that use the same types of input data. Since ESRI (the developer of the ArcView software) is no longer updating the ArcView 3.x software, there is a general trend away from ArcView 3.X and towards ArcView 8.X (and 9.X).

3.0 GSSHA

GSSHA is a physically-based, distributed-parameter model that simulates the hydraulic response of watersheds to a given hydrometeorological condition. The major components of the model include:

- Precipitation (spatial and temporal variation)
- Precipitation interception
- Snow fall accumulation and melting
- Infiltration
- Evapotranspiration
- Overland flow routing
- Groundwater flow
- Channel routing
- Overland Sediment erosion / deposition
- In-stream sediment transport

A detailed description of how these processes are treated within the model are described in USACE (2005), the GSSHA users manual developed by Downer and Ogden (2002) and the folloing page fromn the Coastal and Hydraulics Laboratory CHL from the USACE. http://chl.erdc.usace.army.mil/gssha .

This manual was designed to help Clinton watershed managers in the application and interpretation of GSSHA numerical model and is organized by different processes. For simplicity and because the events modeled were during the summer months, evapotranspiration and snowfall accumulation and melting were not included in the simulation process.

There are two main files that the user needs to understand in order to run GSSHA properly: The project file and the Index map tables.

3.1 The Project File (*.prj)

This file contains the main information to run GSSHA which includes the file names for all the parameters and basic information regarding grid size, time step etc. Figure 3.1 depicts a typical project file. The user should NOT change the red lines or “cards”.

MAP_FREQ and HYD_FREQ specify the frequency (in number of time steps) for file output writing.

```
CASC2DPROJECT
WMS 6.1
WATERSHED_MASK          paint8_gar17k.msk
FLINE                   paint8_gar17k.map
METRIC
GRIDSIZE                49.829661
ROWS                    257
COLS                    267
TOT_TIME                5760
TIMESTEP                20
OUTROW                  256
OUTCOL                  255
OUTSLOPE                0.001000
MAP_FREQ                360
HYD_FREQ                180
MAP_TYPE                1
CHAN_EXPLIC
SED_POROSITY            0.400000
ELEVATION               paint8_gar17k.ele
DEPTH                   paint8_gar17k.dep
INCLUDE_CHANNEL_DEPTH
INF_DEPTH               paint8_gar17k
CHAN_DEPTH              paint8_gar17k.cdp
CHAN_DISCHARGE          paint8_gar17k.cdq
CHANNEL_INPUT           paint8_gar17k.cip
LINKS                   paint8_gar17k.lks
NODES                   paint8_gar17k.nod
DIS_PROFILE             paint8_gar17k.qpf
WAT_SURF_PROFILE        paint8_gar17k.wpf
OVERTYPE                ADE
INF_REDIST
MAPPING_TABLE           paint8_gar17k.cmt
MATERIALS               paint8_gar17k.mat
GW_SIMULATION
AQUIFER_BOTTOM          paint8_gar17k.aqe
WATER_TABLE             paint8_gar17k.wte
GW_HYCOND_MAP           paint8_gar17k.hdc
GW_POROSITY_MAP         paint8_gar17k.gwp
GW_BOUNDFILE            paint8_gar17k.bnd
GW_TIMESTEP             60.000000
GW_LSOR_DIR             2
GW_LSOR_CON             0.000010
GW_RELAX_COEFF          1.200000
GW_LEAKAGE_RATE         0.000000
GW_INIT_MOISTURE        0
SUMMARY                 paint8_gar17k.sum
OUTLET_HYDRO            paint8_gar17k.hyd
OUTLET_SED_FLUX         paint8_gar17k.sed
PRECIP_FILE             paint8_gar17k.gag
SOIL_EROSION
SAND_SIZE               0.250000
SILT_SIZE               0.016000
CLAY_SIZE               0.001000
WATER_TEMP              20.000000
```

```
BRIEF DESCRIPTION

Defines domain extension
River network
Units
Grid size spacing (m)
Number of grid squares in Y
Number of grid squares in X
Modeling time (minutes)
Time step (s)
Outlet Y location
Outlet X Location
Outlet slope
Map frequency output
Hydrograph frequency output
Type of output file 1=ASCII
Modeling scheme
Initial sediment porosity %
Surface elevation map (m)
Overland flow depth (Output)

Infiltration depth (Output)
Channel depth (Output)
Channel Discharge (Output)
Channel network connectivity
Location of channel links
Location of channel nodes
Startup channel discharge
Startup channel discharge
Overland flow scheme
Infiltration method
Mapping table values
Material index

Aquifer bottom elevation
Water table elevation map
GW hydraulic Conductivity
GW porosity map
GW boundary map
Ground water time step
GW flow direction
Convergence parameter
Relaxation coefficient
GW leakage rate
GW Initial moisture
Summary file (output)
Outlet hydrograph
Outlet sediment flux
Precipitation time series

Sand size (mm)
Silt size (mm)
Clay size (mm)
Water temperature C°
```

Figure 3.1 Project file sample (Do not modify red cards)

The ground water time step GW_TIMESTEP can be larger than the overland flow time step. It is recommended that a multiple of the latter be chosen.

WATER_TEMP can be changed but only a constant value can be specified.

3.2 The Index Map Tables

MAPPING_TABLE (*.cmt)

This file contains index data information mainly associated with land use and soil type raster data coverages. Each attribute is assigned with an index value for which different erodability and infiltration parameters can be manipulated. The data shown in **Figure 3.2** depicts an example of a mapping table file.

Each raster map is identified as an index map (*.idx), which is used for different processes throughout the modeling. For example, the land use index map is used to define friction parameters and the soil index map to define infiltration characteristics. For erosion processes, the combination of soil type and land use maps will determine the eroded material quantities.

Roughness (SURF_ROUGH)

This map defines the surface roughness of the model domain. A constant value could be applied to the whole domain but it is more realistic to specify different values for different land use types. For example, paved areas would have a much smaller friction coefficient than densely vegetated areas. The Manning's *n* values usually range from 0.005 to 0.7 depending on the land use type (see Table 3.1 for values). These values can be manipulated within a reasonable range to calibrate the model.

Infiltration (GREEN_AMPT_INFILTRATION)

This parameter is associated mainly with soil type, although in some instances (especially in smaller scale models) land use can play a significant role (e.g. infiltration rate would be different for a driveway than for a lawn regardless of the soil type).

The main parameters considered in this map are:

Hydraulic conductivity (HYDR_COND)
Capillary Head (CAPIL_HEAD)
Porosity (POROSITY)
Pore distribution index (PORE_INDEX)
Residual water content (RESID_SAT)

The most sensitive parameters are the hydraulic conductivity and the capillary head, both of which are used for calibration purposes.

Initial moisture (GREEN_AMPT_INITIAL_SOIL_MOISTURE)
The initial soil moisture can also be specified in SOIL_MOISTURE and it is dependent on the soil type. For this case an assumed value of 0.38 (38% moisture) is used.

Soil Erosion properties (SOIL_EROSION_PROPS)
This erodability parameter is directly related to the soil properties, which include an erodability factor (ERODABILITY), the sand percentage (SAND_PCT) and silt percentage (SILT_PCT) of a particular soil type.

Soil Erosion Factors (SOIL_EROSION_FACTORS)
This set of parameters is related to the land use properties and accounts for management practices through the *C* (CROP_MANAG) and *P* (CONS_PRAC) factors described by the USLE equation. Although the C factor is fairly well defined in the literature and digital data attributes for different land use types, this value can be manipulated to calibrate the model in terms of sediment delivery.

Ground Water Properties
There are four raster maps associated with the ground water flow. All have a similar structure and are described below:

Aquifer Bottom (*.aqe)
This file can be a constant number set to the elevation at which the bedrock is encountered. Since in many instances this is an unknown value, it can be assumed to be at a constant level below the surface. For this case it was assumed to be at 100m.

Water Table (*.wte)
This file contains water table elevation values for each grid cell. Since it is often unknown, an arbitrary value can be assumed (e.g. 10 m below the surface), giving the water table a parallel surface to the elevation map with a fixed vertical displacement. This file influences base flow significantly, thus it can be manipulated to obtain better calibration results. After the model is run, a "hotstart_file" is created which contains a newer more natural water table level. This information can be cut and pasted into the original *wte file. It is our experience that when the model is run for two or more cycles the simulated water table levels produce results closer to measurements. Since the water table is a function of the precipitation history, it is recommended that for each precipitation event to be run by the user, the water table be adjusted to match the pre-event outflow discharge.

Ground Water Hydraulic Conductivity (*.hdc)
This raster map defines the speed at which the groundwater moves in the horizontal plane. The values are associated with the soil properties and can vary throughout the domain. Typical values range from 10 to 40 cm/hr. The hydraulic conductivity is an important parameter for calibration of the base flow. For this case the ground water hydraulic conductivity was assumed constant.

```
GSSHA_INDEX_MAP_TABLES
INDEX_MAP               id_map_3.idx "land use"
INDEX_MAP               id_map_4.idx "soils"
INDEX_MAP               id_map_5.idx "infiltration"
ROUGHNESS "land use"
NUM_IDS 11
ID    DESCRIPTION1                      DESCRIPTION2                          SURF_ROUGH
2     Roughness ID                Residential                                   0.011000
3     Roughness ID                Developed Industrial                          0.013700
8     Roughness ID                Bare Field                                    0.050000
9     Roughness ID                Range (natural)                               0.130000
10    Roughness ID                Range (Clipped)                               0.100000
14    Roughness ID                Small Grain                                   0.150000
15    Roughness ID                Row Crops                                     0.100000
18    Roughness ID                Short GrassPrairie                            0.150000
22    Roughness ID                Forest                                        0.192000
25    Roughness ID                Lakes                                         0.400000
26    Roughness ID                Wetlands                                      0.400000
INTERCEPTION ""
NUM_IDS 0
ID    DESCRIPTION1                      DESCRIPTION2                          STOR_CAPY  INTER_COEF
RETENTION ""
NUM_IDS 0
ID    DESCRIPTION1                      DESCRIPTION2                       RETENTION_DEPTH
GREEN_AMPT_INFILTRATION "infiltration"
NUM_IDS 8
ID    DESCRIPTION1                      DESCRIPTION2                          HYDR_COND  CAPIL_HEAD    POROSITY  PORE_INDEX   RESID_SAT A_REDUX_DEPTH
2     Infiltration ID           Concreete/Asphalt                             0.076000    6.130000    0.401000    0.553000    0.035000    0.000000
3     Infiltration ID           Developed/ Industrial (Loamy Sand)            0.836000    6.130000    0.401000    0.553000    0.035000    0.000000
4     Infiltration ID           Range/Forest/Prairie (Loamy Sand)             1.068000    6.130000    0.401000    0.553000    0.035000    0.000000
5     Infiltration ID           Crops (LoamySand)                             6.004000    6.130000    0.401000    0.553000    0.035000    0.000000
6     Infiltration ID           Lakes Wetlands                               15.000000    6.130000    0.401000    0.553000    0.035000    0.000000
8     Infiltration ID           Developed/ Industrial (Sandy Loam)            0.185000   11.010000    0.434000    0.252000    0.027000    0.000000
9     Infiltration ID           Range/Forest/Prairie (Sandy Loam)             0.235000   11.010000    0.434000    0.252000    0.027000    0.000000
10    Infiltration ID           Crops (SandyLoam)                             1.326000   11.010000    0.434000    0.252000    0.027000    0.000000
GREEN_AMPT_INITIAL_SOIL_MOISTURE "soils"
NUM_IDS 2
ID    DESCRIPTION1                      DESCRIPTION2                       SOIL_MOISTURE
2     Soil Moisture ID                  Sandy Loam                            0.380000
4     Soil Moisture ID                  Loamy Sand                            0.380000
RICHARDS_EQN_INFILTRATION_BROOKS  ""
NUM_IDS 0
MAX_NUMBER_CELLS 0
ID    DESCRIPTION1                      DESCRIPTION2                          HYD_COND    POROSITY   RESID_SAT  SOIL_MOIST  WILTING_PT       DEPTH      LAMBDA   BUB_PRESS     DELTA_Z
RICHARDS_EQN_INFILTRATION_HAVERCAMP  ""
NUM_IDS 0
MAX_NUMBER_CELLS 0
ID    DESCRIPTION1                      DESCRIPTION2                          HYD_COND    POROSITY   RESID_SAT  SOIL_MOIST  WILTING_PT       DEPTH       ALPHA        BETA        AHAV        BHAV     DELTA_Z
EVAPOTRANSPIRATION ""
NUM_IDS 0
ID    DESCRIPTION1                      DESCRIPTION2                            ALBEDO  WILTING_PT  VEG_HIEGHT  V_RAD_COEF CANOPY_RESIST
SOIL_EROSION_PROPS "soils"
NUM_IDS 2
ID    DESCRIPTION1                      DESCRIPTION2                       ERODIBILITY    SAND_PCT    SILT_PCT
2     Soil erosion properties ID        Sandy Loam                            0.270000    0.650000    0.250000
4     Soil erosion properties ID        Loamy Sand                            0.120000    0.800000    0.150000
SOIL_EROSION_FACTORS "land use"
NUM_IDS 11
ID    DESCRIPTION1                      DESCRIPTION2                       CROP_MANAG  CONS_PRACT
2     Soil erosion factors ID     Concreete/Asphalt                             0.005000    0.400000
3     Soil erosion factors ID     Developed/ Industrial                         0.003000    0.400000
8     Soil erosion factors ID     Bare Field                                    0.300000    0.400000
9     Soil erosion factors ID     Range (Natural)                               0.010000    0.400000
10    Soil erosion factors ID     Range (Clipped)                               0.010000    0.400000
14    Soil erosion factors ID     Small Grain                                   0.070000    0.400000
15    Soil erosion factors ID     Row Crops                                     0.120000    0.400000
18    Soil erosion factors ID     Short Grass Prairie                           0.003000    0.400000
22    Soil erosion factors ID     Forest                                        0.011000    0.400000
25    Soil erosion factors ID     Lakes                                         0.000100    0.400000
26    Soil erosion factors ID     Wetlands                                      0.001000    0.400000
MATERIAL_INDEX
NUM_IDS 0
ID    DESCRIPTION                          AQUIF_BTM   WATER_TBL   GW_HYCOND GW_POROSITY   CELL_ELEV
```

Figure 3.2 Index-Map-Tables File Sample.

Ground Water Porosity (*.gwp)
This file contains the initial porosity of the soil (1.0 being the highest value).

Table 3.1. GSSHA Surface Roughness Coefficients for Overland Flow (*All Models*)

Land Use Type	Paint Creek		Galloway Creek		Middle Branch	
	ID	Value	ID	Value	ID	Value
Residential	2	0.011	12	0.011	12	0.011
Developed/ Industrial	3	0.0137	13	0.0137	13	0.0137
Bare Field	8	0.050	77	0.050	8	0.050
Range (natural)	9	0.130	N/A	0.130	32	0.130
Range (Clipped)	10	0.100	N/A	0.100	33	0.100
Small Grain	14	0.150	N/A	0.150	N/A	N/A
Row Crops	15	0.100	22	0.100	22	0.100
Short Grass Prairie	18	0.150	N/A	0.150	N/A	N/A
Forest	22	0.192	42	0.192	43	0.192
Lakes	25	0.400	53	0.400	53	10.00
Wetlands	26	0.400	53	0.400	62	0.400
Strip Mines, Quarries	N/A	0.020	76	0.020	N/A	0.020

Table 3.2. GSSHA Crop Management (Soil Erosion) Factor (*All Models*)

Land Use Type	Paint Creek		Galloway Creek		Middle Branch	
	ID	Value	ID	Value	ID	Value
Concrete/ Asphalt	2	0.005	N/A	N/A	N/A	N/A
Developed/ Industrial	3	0.003	13	0.003	13	0.003
Bare field	8	0.300	77	0.300	8	0.300
Range (natural)	9	0.010	N/A	N/A	32	0.010
Range (clipped)	10	0.010	N/A	N/A	33	0.010
Small grain	14	0.070	N/A	N/A	N/A	N/A
Row crops	15	0.120	22	0.120	22	0.120
Short grass prairie	18	0.003	N/A	N/A	N/A	N/A
Forest	22	0.011	42	0.011	43	0.011
Lakes	25	0.0001	53	0.0001	53	0.0001
Wetlands	26	0.001	53	0.001	62	0.001
Strip Mines, Quarries	N/A	0.020	76	0.020	N/A	N/A

Table3.3. GSSHA Model Infiltration Indices and Values (cm/hour) *Paint Creek*

Land use type	Soil Type			
	Sandy loam		Loamy sand	
	ID	Value	ID	Value
Concrete or asphalt	2	0.076	2	0.076
Developed/Industrial	8	0.185	3	0.836
Range/Forest/ Prairie	9	0.235	4	1.068
Crops	10	1.326	5	6.004
Lakes / Wetlands	6	15.00	6	15.00

Table 3.4 GSSHA Model Infiltration Indices and Values (cm/hour) *Galloway Creek*

Land use type	Soil Type							
	Sandy loam (MI029)		Loamy sand (MI014)		Loam-Sandy loam (MI016)		Loam (MI010)	
	ID	Value	ID	Value	ID	Value	ID	Value
Lakes / Wetlands	N/A	0.0000	N/A	0.0000	N/A	0.0000	23	0.0000
Transportation	8	0.0168	14	0.0336	N/A	0.0112	16	0.0084
Developed/Industrial	20	0.0168	3	0.0336	6	0.0112	21	0.0084
Residential (high density)	N/A	0.0624	N/A	0.1248	N/A	0.0416	N/A	0.0312
Residential	13	0.0912		0.1824	N/A	0.0608	18	0.0456
Agriculture	N/A	0.1200	N/A	0.2400	N/A	0.0800	N/A	0.0600
Range/Forest/ Prairie/Crops	7	0.1200	2	0.2400	1	0.0800	6	0.0600

Table 3.5. GSSHA Model Infiltration Values (cm/hour) *Middle Branch*

Land use type	Soil Association / Type					
	Loamy Sand	Fine Sandy Loam	Loam	Sandy Loam	Clay Loam	Clay
Lakes / Wetlands	0.000	0.000	0.000	0.000	0.000	0.000
Transportation	0.034	0.002	0.001	0.001	0.001	0.000
Developed/Industrial	0.034	0.012	0.009	0.007	0.004	0.003
Residential (high density)	0.125	0.084	0.068	0.049	0.030	0.023
Residential	0.182	0.162	0.130	0.094	0.058	0.043
Agriculture	0.228	0.214	0.171	0.124	0.076	0.057
Range/Forest/ Prairie/Crops	0.240	0.225	0.180	0.130	0.080	0.060

Table 3.6 GSSHA Model Infiltration Indices *Middle Branch*

Land use type	Soil Association / Type					
	Loamy Sand	Fine Sandy Loam	Loam	Sandy Loam	Clay Loam	Clay
Lakes / Wetlands	553	753	453	653	353	253
Transportation	515	715	415	615	315	215
Developed/Industrial	514	714	414	614	314	214
Residential (high density)	516	716	416	616	316	216
Residential	512	712	412	612	312	212
Agriculture	520	720	420	620	320	220
Range/Forest/ Prairie/Crops	522	722	422	622	322	222

Precipitation PRECIP_FILE (*.gag)
This file contains information about precipitation time series for the simulation period. A formatted sample file is shown below.

Precipitation can be input in different forms depending on the available data as well as the purpose of the simulation. The precipitation can be a constant in time and space, varying in time and space or varying in time and constant in space. Since there was sufficient temporal data for the modeled basins and the domain areas were significantly small, a constant in space and varying in time precipitation record was created (Figure 3.3).

```
EVENT "Event Name"
NRGAG 1
NRPDS 300
COORD 0.0 0.0 "no name" "Event Name"
RATES 1986 9 21 0 0  0.000000
RATES 1986 9 21 1 0  0.000000
RATES 1986 9 21 2 0  0.000000
RATES 1986 9 21 3 0  0.000000
RATES 1986 9 21 4 0  0.000000
RATES 1986 9 21 5 0  0.000000
RATES 1986 9 21 6 0  0.000000
RATES 1986 9 21 7 0  0.000000
RATES 1986 9 21 8 0  0.000000
RATES 1986 9 21 9 0  0.000000
```

```
Name of Event
Number of utilized gages
Number of precip.  Data points
Gage Coordinates UTM
Year Month Day hr min value (mm)
```

Figure 3.3. Constant Spatial Precipitation Record Sample File.

For evaluating the different BMPs at the small-scale resolution, a constant precipitation record in time and space was specified. When constant precipitation is utilized, the user must implement the following changes to the project (*.prj) file.

At the precipitation section on the project file,

```
OUTLET_SED_FLUX          paint8_gar17k.sed
PRECIP_FILE              paint8_gar17k.gag
SOIL_EROSION
```

the user should delete the PRECIP_FILE row and substitute in the following form,

```
OUTLET_SED_FLUX          buf6_inf_snodevelop2.sed
PRECIP_UNIF
RAIN_INTENSITY           30.000000
RAIN_DURATION            180
START_DATE               1994 1 1
START_TIME               12 0
SOIL_EROSION
```

where the RAIN_INTENSITY is given in mm per hour, the RAIN_DURATION given in minutes and followed by the start date (yyyy mm dd) and time (hh mm).

3.3 GSSHA Land Use Change Tutorial

The GSSHA model can be run within the WMS software, but since this is proprietary software, it was desired to have a way to modify the GSSHA land use grid without needing the WMS software. Because the ArcView 3.x software is more commonly used than WMS, an extension was developed for ArcView 3.x that allows the user to import an existing GSSHA land use grid, edit it, and output a new grid ready to be run in GSSHA.

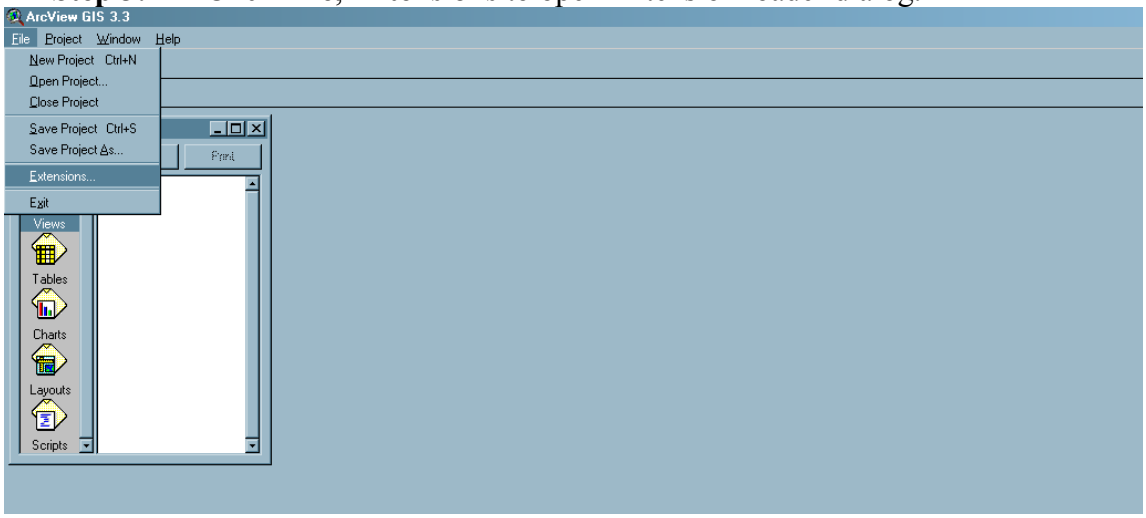
This tutorial will overwrite some of the existing GSSHA datasets. To assure that the original datasets are preserved, it is advisable to copy the entire subfolder of files, and save to a new subfolder (Note, the sub folder and folder path must not have spaces in the title). It is also a good practice to rename the subfolder to a descriptive name, in order to identify the scenario that is being modeled.

The red boxes on the following screen images show where the user needs to click or type; the yellow boxes are to draw the users attention (no action is required); and the red numbers indicate the order in which the actions need to occur.

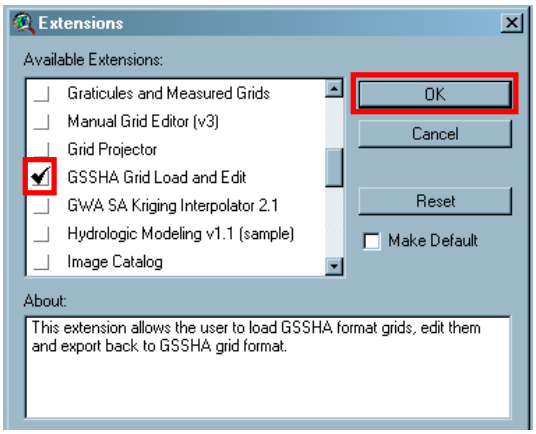
Step 1: Copy GSSHAgrid.avx and gridedit.avx from CD and paste into the ArcView EXT32 folder (commonly *C:\ESRI\AV_GIS30\ARCVIEW\EXT32)*

Step 2: Open ArcView 3.x.

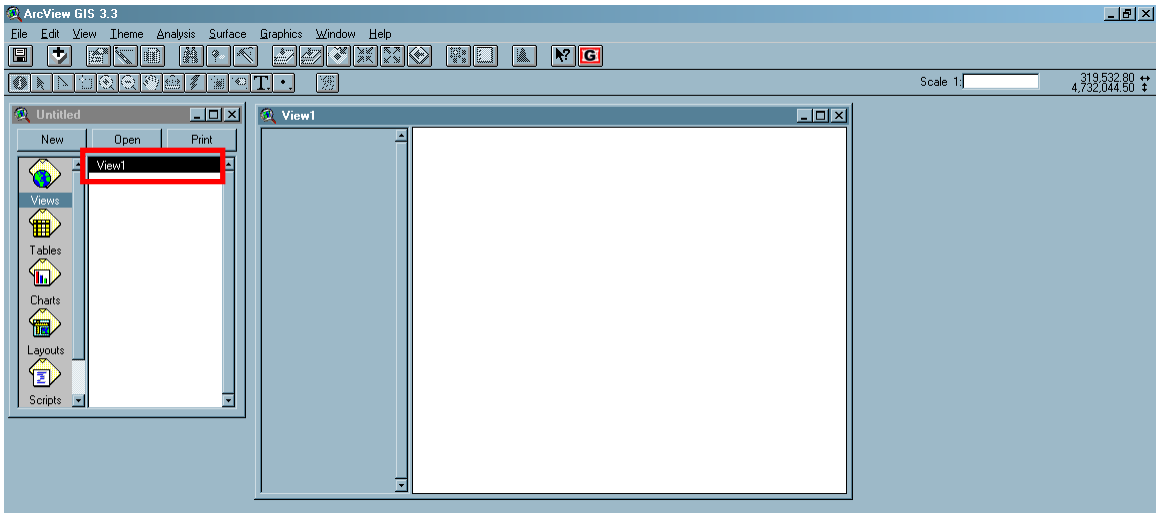
Step 3: Click **File**, **Extensions** to open Extension loader dialog.



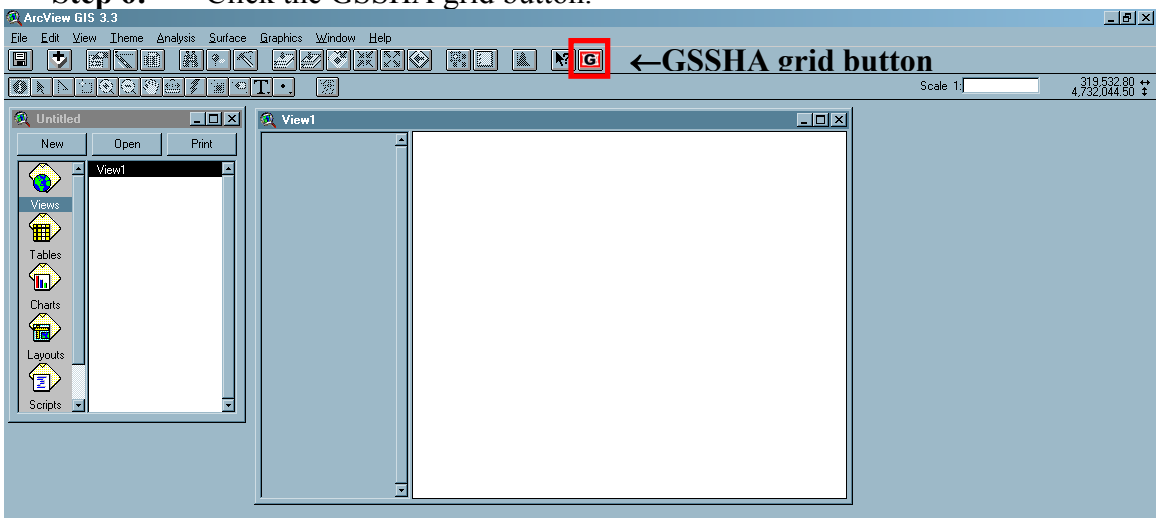
Step 4: Click the box next to **GSSHA Grid Load and Edit** then click OK.



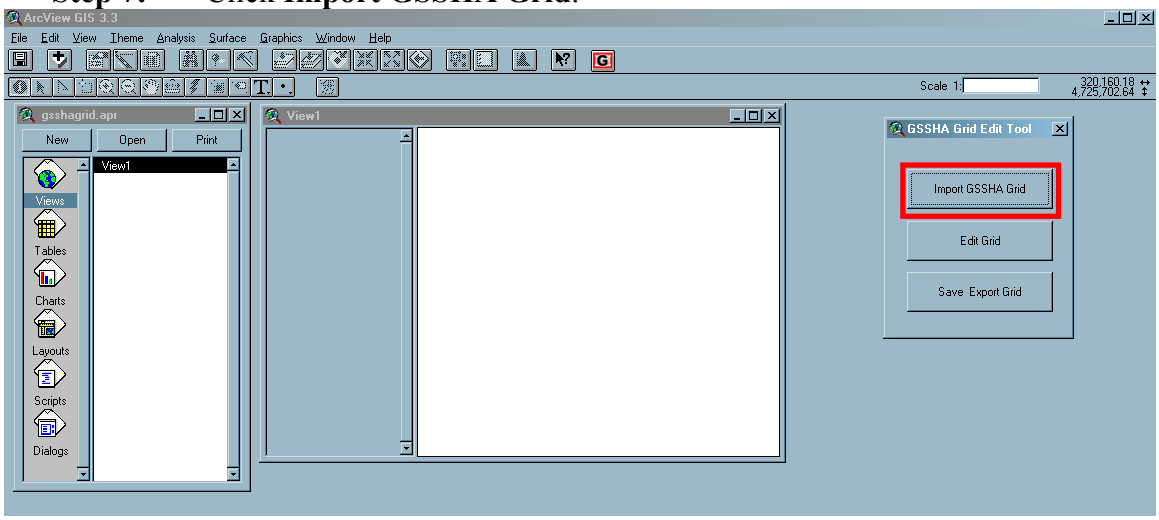
Step 5: Double-click on **View1** to open the view.



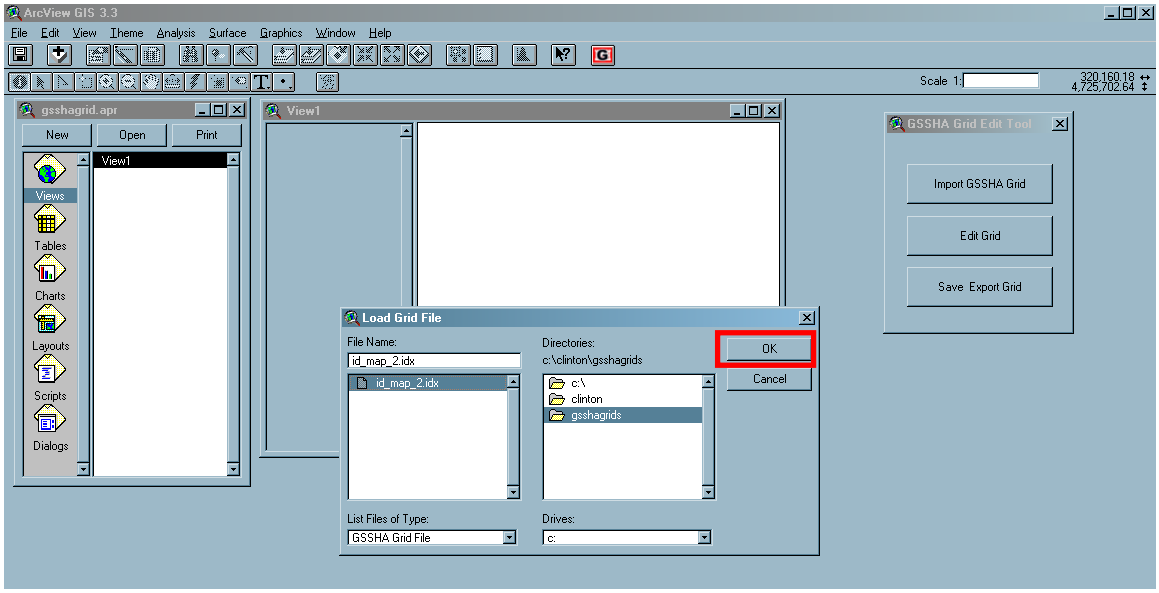
Step 6: Click the GSSHA grid button.



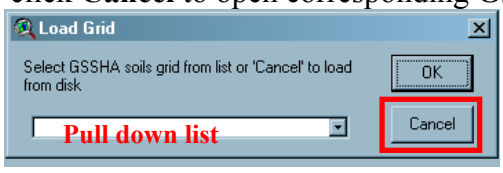
Step 7: Click **Import GSSHA Grid**.

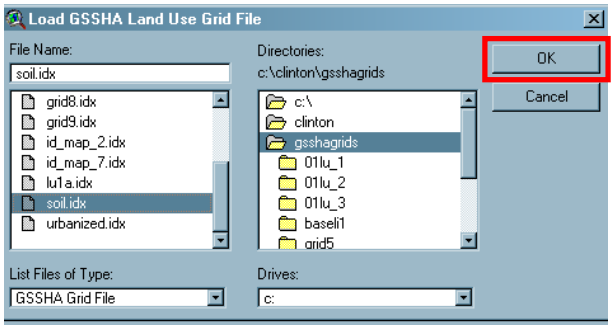


Step 8: Browse to the folder containing the GSSHA grid .idx file, select file and click **OK**.

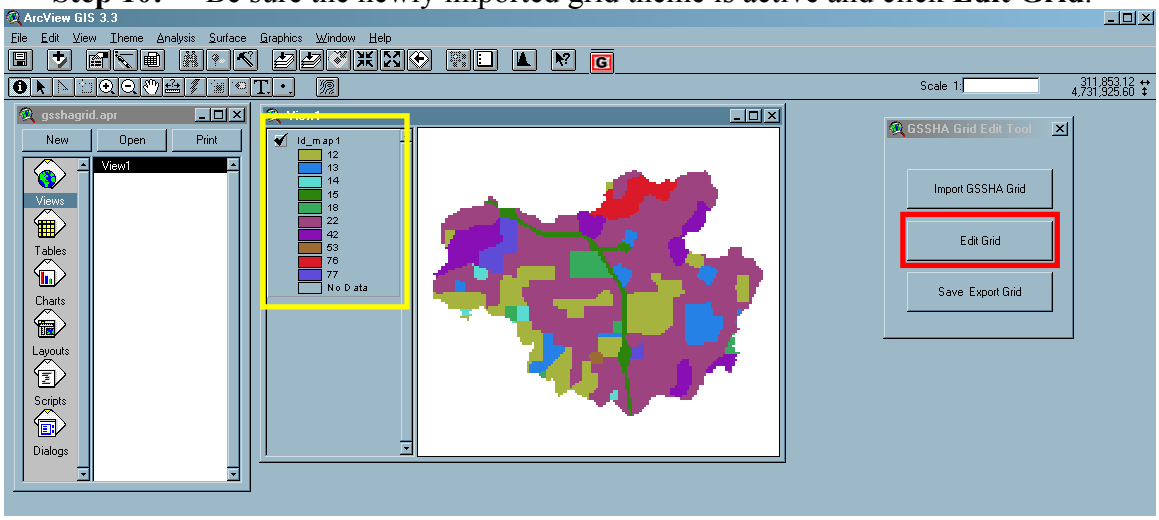


Step 9: If soils theme is already in the View, select it from the pull down list, otherwise click **Cancel** to open corresponding GSSHA soils grid (*.idx).

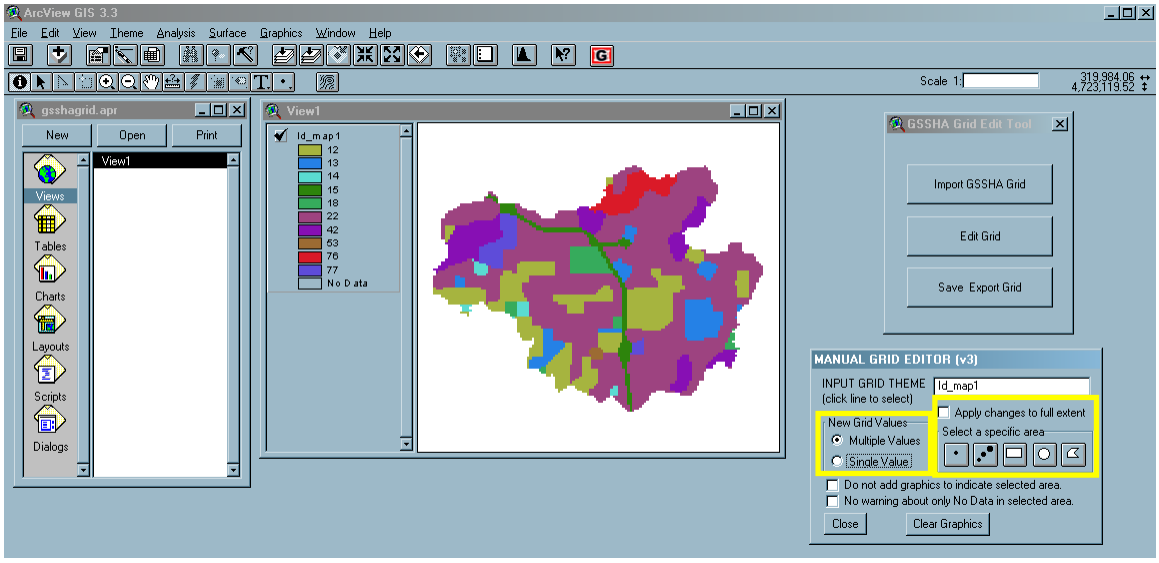


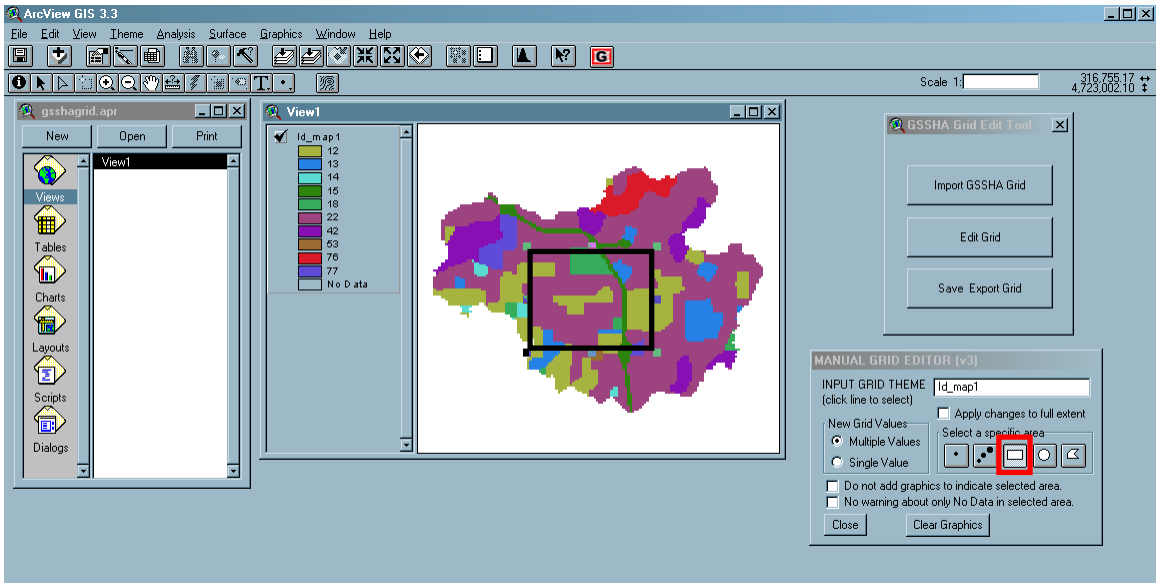


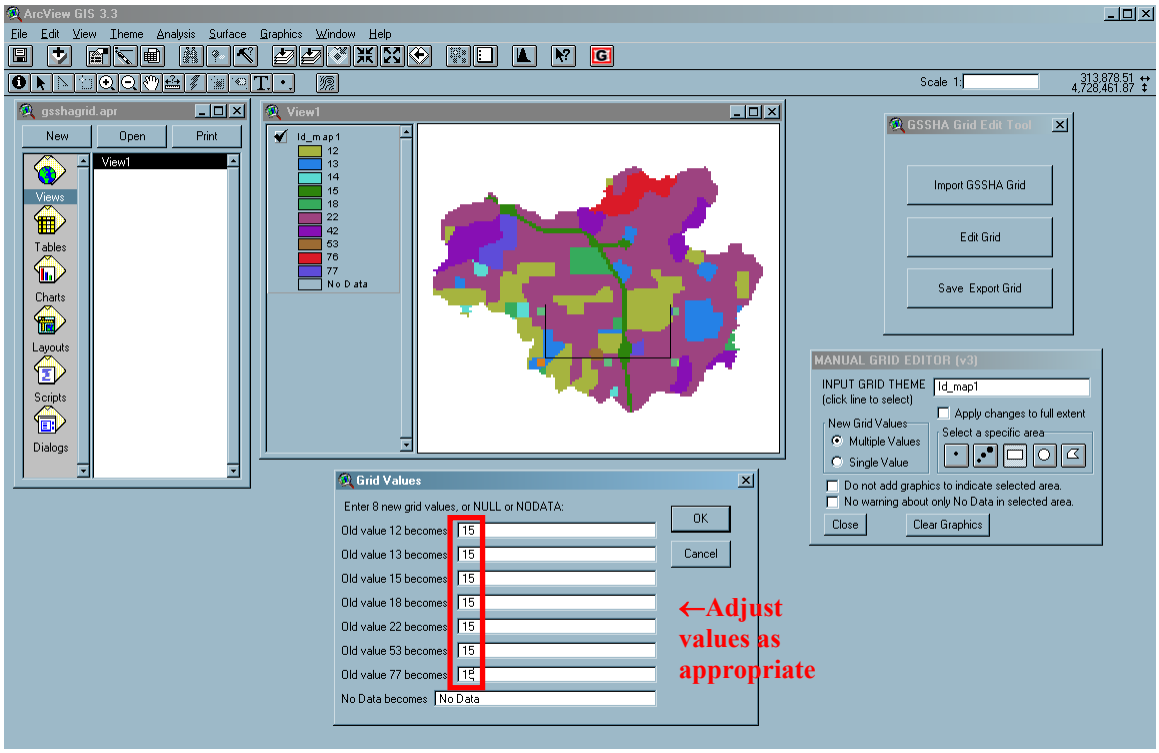
Step 10: Be sure the newly imported grid theme is active and click **Edit Grid**.

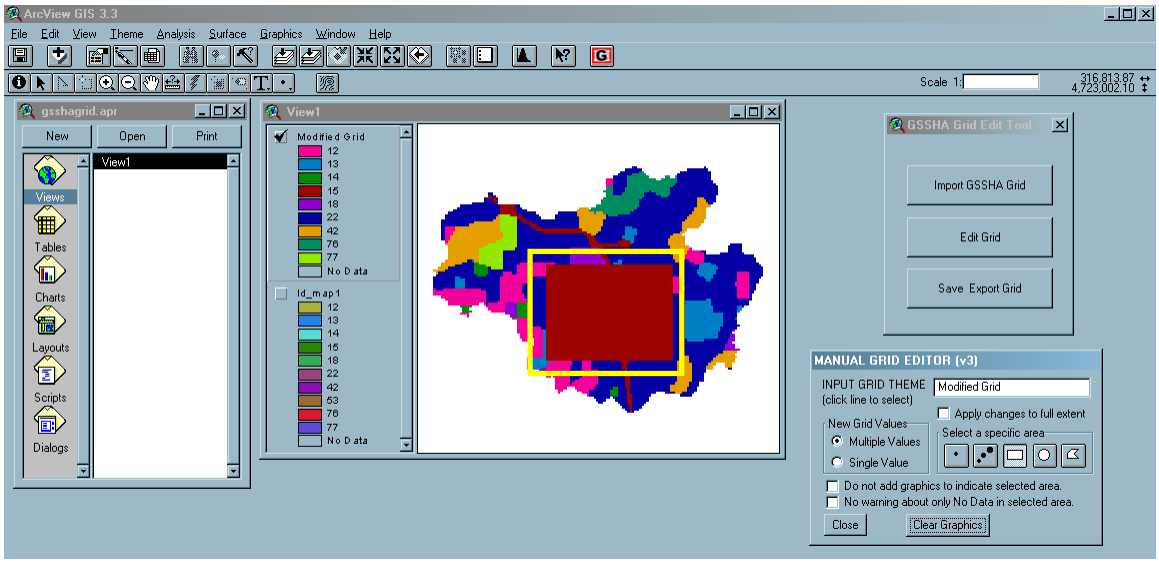


Step 11: Specify whether to edit entire grid or just a portion (using shape tools to select area) and whether to edit multiple or single values. Make edits; this will create a new grid called **Modified Grid**.

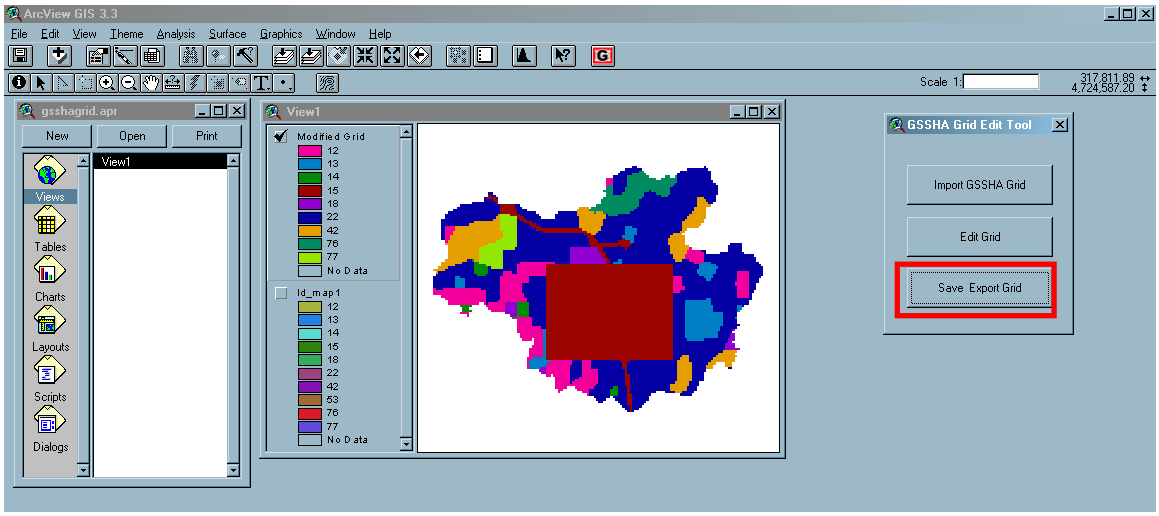

ArcView GIS 3.3
File Edit View Theme Analysis Surface Graphics Window Help
Scale 1:
319,984.06
4,723,119.52
gsshagrid.apr
New
Open
Print
Views
Tables
Charts
Layouts
Scripts
Dialogs
View1
View1
Id_map1
12
13
14
15
18
22
42
53
76
77
No Data
GSSHA Grid Edit Tool
Import GSSHA Grid
Edit Grid
Save Export Grid
MANUAL GRID EDITOR (v3)
INPUT GRID THEME
(click line to select)
Id_map1
Apply changes to full extent
New Grid Values
Multiple Values
Single Value
Select a specific area
Do not add graphics to indicate selected area.
No warning about only No Data in selected area.
Close
Clear Graphics


ArcView GIS 3.3
File Edit View Theme Analysis Surface Graphics Window Help
Scale 1:
316,755.17
4,723,002.10
gsshagrid.apr
New
Open
Print
Views
Tables
Charts
Layouts
Scripts
Dialogs
View1
View1
Id_map1
12
13
14
15
18
22
42
53
76
77
No Data
GSSHA Grid Edit Tool
Import GSSHA Grid
Edit Grid
Save Export Grid
MANUAL GRID EDITOR (v3)
INPUT GRID THEME
(click line to select)
Id_map1
Apply changes to full extent
New Grid Values
Multiple Values
Single Value
Select a specific area
Do not add graphics to indicate selected area.
No warning about only No Data in selected area.
Close
Clear Graphics

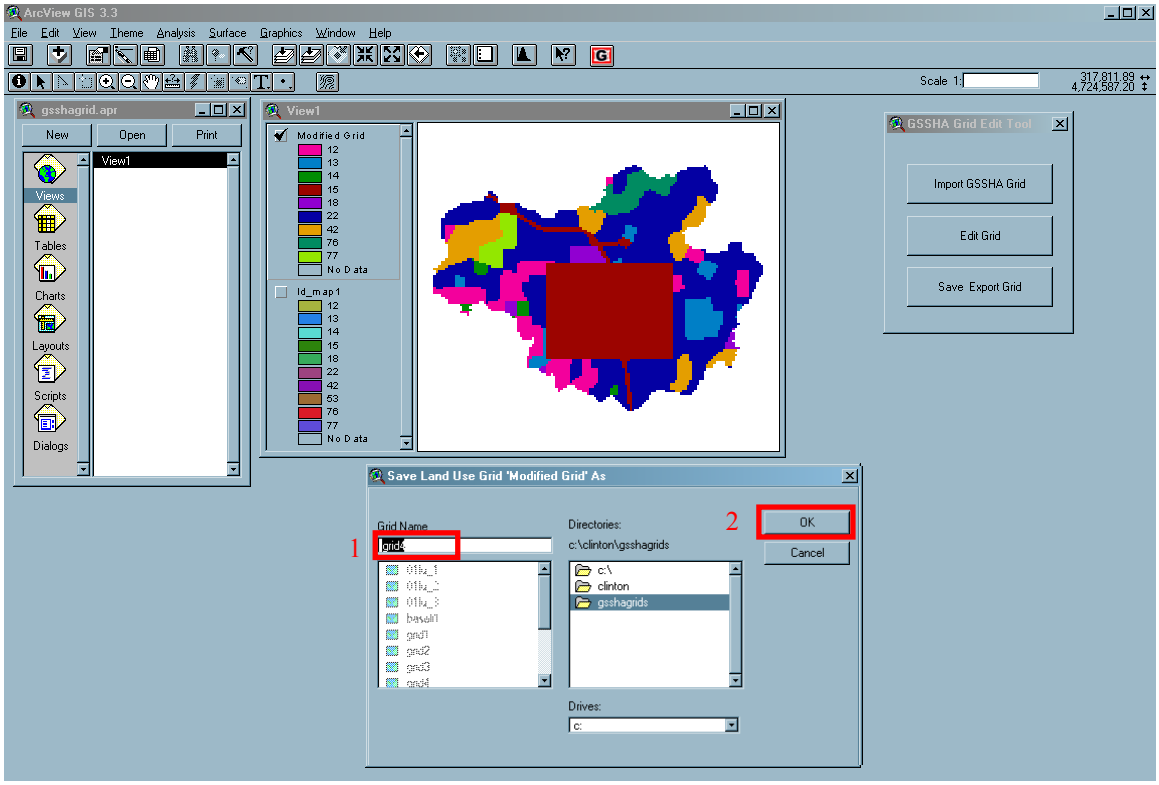

ArcView GIS 3.3
File Edit View Theme Analysis Surface Graphics Window Help
gsshagrid.apr
New Open Print
Views Tables Charts Layouts Scripts Dialogs
View1
Id_map1
12 13 14 15 18 22 42 53 76 77 No Data
GSSHA Grid Edit Tool
Import GSSHA Grid
Edit Grid
Save Export Grid
MANUAL GRID EDITOR (v3)
INPUT GRID THEME (click line to select)
Id_map1
Apply changes to full extent
New Grid Values
Multiple Values
Single Value
Select a specific area
Do not add graphics to indicate selected area.
No warning about only No Data in selected area.
Close
Clear Graphics
Grid Values
Enter 8 new grid values, or NULL or NODATA:
Old value 12 becomes 15
Old value 13 becomes 15
Old value 15 becomes 15
Old value 18 becomes 15
Old value 22 becomes 15
Old value 53 becomes 15
Old value 77 becomes 15
No Data becomes No Data
OK
Cancel
←Adjust values as appropriate


ArcView GIS 3.3
File Edit View Theme Analysis Surface Graphics Window Help
gsshagrid.apr
New Open Print
Views Tables Charts Layouts Scripts Dialogs
View1
Modified Grid
12 13 14 15 18 22 42 76 77 No Data
Id_map1
12 13 14 15 18 22 42 53 76 77 No Data
GSSHA Grid Edit Tool
Import GSSHA Grid
Edit Grid
Save Export Grid
MANUAL GRID EDITOR (v3)
INPUT GRID THEME (click line to select)
Modified Grid
Apply changes to full extent
New Grid Values
Multiple Values
Single Value
Select a specific area
Do not add graphics to indicate selected area.
No warning about only No Data in selected area.
Close
Clear Graphics

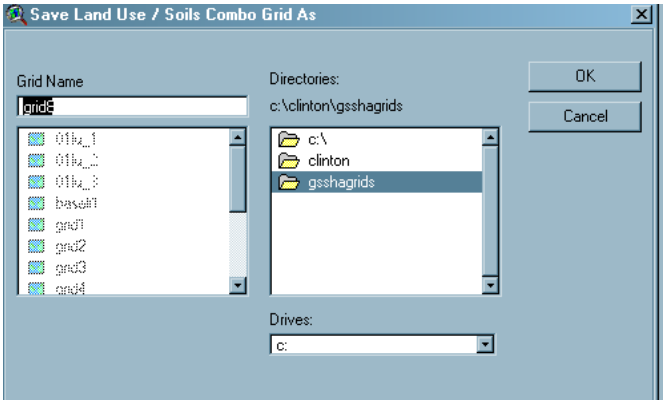
Step 12: When finished editing, click **Save Export Grid**.



Step 13: Specify name for new GSSHA land use grid and click **OK**. This will create a new GSSHA land use grid file (.idx) that can be used in a new GSSHA run.



Step 14: Specify new name for the GSSHA land use / soils combo grid and click **OK**. This will create another .idx file to be used in the new GSSHA model run.



Step 15: Substitute the old files in the GSSHA project folder with the newly generated files. Make sure to keep a backup of the original land use, soil and soil/landuse grid fileas at all times.

3.4 Running GSSHA

Once the mapping files have been modified and saved, as described in the previous Steps 1 through 15, the GSSHA simulation is ready to run. The GSSHA executable file (gssha.exe) runs in a DOS window, and is easiest to execute with an MS-DOS batch file (*.bat). The content of this batch file is one line, "gssha *.prj" where the * is replaced with the name of the project file. There are many ways to run this batch file, including opening a DOS window and running the model in that window, or by double left-clicking the batch file in Windows Explorer. In either case, once the batch file is successfully executed, other windows will open that will show the progress of the simulation. One window will show a graphical representation of the overland flow simulation and channel discharge that is color-coded. The other half of that same window will be a flow hydrograph at the mouth of the subbasin. In a separate window, the time step and outflow will be shown numerically.

Once the GSSHA run is complete, the following files will contain relevant output data:

- The *.sum file will contain summary information from the simulation;
- The *.hyd file will contain the runoff hydrogaph for the mouth of the subbasin.
- The *.sed file will contain the sediment delivered to the mouth, sometimes referred to as the sedimentgraph.

3.5 GSSHA output interpretation

Summary file (*.sum)
This file is generated at the end of the simulation and it gives peak flow date and discharge (in m^3/s) and total volumes of eroded, delivered and exported sediment, (separated in sand, silt and clay) and precipitation, infiltration, exfiltration, runoff and outlet discharge volumes in m^3.

Hydrograph file (*.hyd)
This file contains discharge quantities in (m^3/s) for every HYD_FREQ time step which is given in simulation time steps (e.g. If TIMESTEP=20s and HYD_FREQ=180, the hydrograph values will have an hourly output). This file consists of two columns (the first being the time (min) and the second one being discharge at the watershed outlet).

Sediment load file (*.sed)
This file has a similar structure as the *.hyd file but contains three columns. The first column is time (min), second column is sand flux (m^3/s) and the third column is suspended sediment flux (m^3/s).

The sediment hydrograph and sediment load time series can be imported into excel as text file to generate plots.

4.0 GIS PROJECTS

As part of the Clinton River Watershed Study, a GIS project of all GIS data acquired for the study was created. Some of the GIS data layers were used as inputs to the numerical models. An ArcView 3.x project was set up as part of the Clinton River watershed SWAT model. Only the data layers necessary to run the SWAT model are included in the project. Additional GIS layers were complied into an ArcView 8.x project (which is also compatible with the ArcView 9.X software). Table 4.1 lists the GIS layers and gives some descriptive information about them. All GIS data layers and project files are included on the accompanying CD-ROM.

Table 4.1. GIS Data Layer Listing

Description	Year	Source	Filename	Spatial Extent	Used in Model	Website	Metadata
Digital Ortho Photos - Color	1998	USGS	numerous	Watershed-wide		http://www.mcgi.state.mi.us/mgdl/	yes
Satellite Imagery	1992, 1994		Macomb_tm_image_30m_1992.exe, Oakland_tm_image_30m_1992.exe,Lapeer_tm_image_30m_1992.exe,Wayne_tm_image_30m_1992.exe,St_Clair_tm_image_30m_1992.exe	Macomb and Oakland Counties		http://www.mcgi.state.mi.us/mgdl/	no
BASINS data	varies	EPA	numerous	Watershed-wide	SWAT, WCS	http://www.epa.gov/docs/ostwater/BASINS/	yes
National Elevation Dataset	1999	USGS	Clinton.zip	Watershed-wide	SWAT, WCS	http://seamless.usgs.gov	yes
National Hydrography Dataset - Medium Resolution	1995	USGS/EPA	NHD15719.zip	Watershed-wide		http://nhdgeo.usgs.gov	yes
RF3 River Linework		EPA	04090003.shp, 04090003_sp.shp	Watershed-wide	SWAT, WCS		no
1978 Land Use/ Cover Data	1978-1985	MDNR	oakland_landuse.shp, saint_clair_landuse.shp, wayne_landuse.shp, macomb_landuse.shp, lapeer_landuse.shp	Macomb, Oakland, Lapeer, St. Clair & Wayne Counties	SWAT	http://www.mcgi.state.mi.us/mgdl/	yes
1992 Michigan Land Cover Data Set	1989-1995	USGS	30611567.zip	Watershed-wide	SWAT	http://seamless.usgs.gov	yes
TIGER Roads	2000	U.S. Bureau of the Census	at_tigeresri602713551.zip	Macomb, Oakland, Lapeer, St. Clair & Wayne Counties	WCS	http://arcdata.esri.com/data/tiger2000/tiger_download.cfm	yes
SSURGO Soils	2003	NRCS		Macomb, Oakland, Lapeer, St. Clair & Wayne Counties		http://www.ncgc.nrcs.usda.gov/branch/ssb/products/ssurgo/data/mi.html	yes
STATSGO Soils	1994	NRCS	statsgo_mi_sp.shp	Michigan	SWAT, WCS	http://www.epa.gov/docs/ostwater/BASINS/	yes
HUC14 Watersheds	1986-1997	MDEQ/MDNR	12_sp.shp	Watershed-wide	SWAT, WCS	http://www.mcgi.state.mi.us/mgdl/	yes
Flood Insurance Rate Maps	1996	FEMA	oakland_firm.shp, macomb_firm.shp	Oakland and Macomb Counties		http://www.mcgi.state.mi.us/mgdl/	yes
1987 Bedrock Geology	1987	MDEQ	1987_bedrock_geology.shp	Michigan		http://www.mcgi.state.mi.us/mgdl/	yes
National Wetlands Inventory	1971	US Fish & Wildlife Service	LAPEER_NWI_24K.shp,MACOMB_NWI_24K.shp,OAKLAND_NWI_24K.shp,SAINT_CLAIR_NWI_24K.shp,WAYNE_NWI_24K.shp	Macomb, Oakland, Lapeer, St. Clair & Wayne Counties		http://www.mcgi.state.mi.us/mgdl/	yes

5.0 REFERENCES

Di Luzio, M., Srinivasan, R., Arnold, J.G. 2001. ARCVIEW Interface for SWAT 2000 User's Guide. Blackland Research Center. Texas Agricultural Experiment Station, Temple, Texas.

Downer, C.W., and Ogden, F.L. 2002. GSSHA Users Manual, US Army Engineer Research and Development Center.

Kirsch, K., Kirsch, A., Arnold, J.G. 2002. Predicting Sediment and Phosphorus Loads in the Rock River Basin Using SWAT. *Transactions of the ASAE* Vol. 45(6): 1757-1769.

Neitsch, S.L., Arnold, J.G., Kiniry, J.R., Srinivasan, R., Williams, J.R. 2002a. Soil and Water Assessment Tool User's Manual, Version 2000. Blackland Research Center. Texas Agricultural Experiment Station, Temple, Texas.

Neitsch, S.L., Arnold, J.G., Kiniry, J.R., Williams, J.R., King, K.W. 2002b. Soil and Water Assessment Tool Theoretical Documentation, Version 2000. Blackland Research Center. Texas Agricultural Experiment Station, Temple, Texas.

USACE. 2005. Clinton River Sediment Transport Modeling Study. U.S. Army Corps of Engineers, Great Lakes Hydraulics and Hydrology Office, Detroit District. Contract No. DACW35-01-D-0009/0012. 161pp

Vaché, K.B., Eilers, J.M., Santelmann, M.V. 2002. Water Quality Modeling of Alternative Agricultural Scenarios in the U.S. Corn Belt. Journal of the American Water Resources Association Vol. 38(3): 773-787.

APPENDIX UM1
SWAT PEER REVIEWED PUBLICATIONS

APPENDIX UM2
INSTRUCTIONS TO INSTALL MANUAL GRID EDITOR ARCVIEW EXTENSION

INSTALLATION OF MANUAL GRID EDITOR ARCVIEW EXTENSION

The user should first check to see if the Manual Grid Editor extension is already installed on their computer. This can be done by opening ArcView 3.x, clicking on "File" then on "Extensions". If "Manual Grid Editor" is already in the list of extensions, the user does not need to install it and can skip to the final paragraph in the section explaining how to turn the extension on.

The Manual Grid Editor extension can be downloaded from the ESRI website: http://arcscripts.esri.com/details.asp?dbid=11114, or it can be copied from the accompanying CD-ROM (filename: gridedit.avx).

To install the extension, simply copy the file (gridedit.avx) to the ArcView extension folder: *drive*:\ESRI\AV_GIS30\ARCVIEW\EXT32.

To turn on the extension, open ArcView 3.2, click "File" then "Extensions". Find "Manual Grid Editor (v3)" in the list and click the adjacent box to turn it on. This will have to be done each time you create a new ArcView project (i.e., it is not on by default).

To use the Manual Grid Editor, go to the Analysis menu and click "Manual Grid Editor".